THE PAST HISTORY AND PRESENT POSITION OF THE BITTER PIT QUESTION.

BY D. McALPINE.

FIRST PROGRESS REPORT.

1911-12.

FRONTISPIECE

LORD WOLSELEY. COX'S ORANGE PIPPIN.

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I.—INTRODUCTION.

The diseases to which our various cultivated fruits are subject have only attracted general attention since they have been grown on a comparatively large scale, for when grown merely for domestic use the relatively small number that were unfit for consumption did not count for much from a monetary point of view, although the loss was keenly felt. But when cultivation was extended and the products became of commercial importance, then the losses came to be reckoned in financial terms, and it was felt that, in order to secure profits, it was necessary to avoid losses by disease or otherwise as much as possible.

Confining our attention to the Apple, which is the particular fruit to be considered here, as orchards increased in size and apple-growing became a recognised industry, there was a corresponding awakening on the part of the orchardist to the numerous foes with which he had to contend.

At first, in the absence of any definite knowledge, the nature and cause of disease were shrouded in mystery, and the ancients often associated it with an offended deity, or regarded it as the working of an evil spirit or humour which entered into the plant and deranged its functions. Then, in more recent times, the weather was held responsible for the majority of diseases, and since the weather could not be controlled, the hopeless apathy thus engendered found expression in the common saying, "What can't be cured, must be endured."

But some of the more intelligent and observant orchardists recognised that while the soil and the climate, the heat, and the moisture may affect the fruit injuriously, there are other agencies at work, such as various living organisms, which may induce disease and even cause the death of the trees.

The action of insects in destroying the fruit was too patent to escape observation, and the worm-eaten apples due to the Codlin moth were familiar objects in the orchard, until a preventive was found in spraying with arsenical compounds.

The parasitic fungi which play such an important part in producing disease are usually very small or microscopic forms, and their power for mischief was not recognised so readily or so early as in the case of insects. But here, also, the union of exact observation with experiment and the scientific study of the particular organisms causing the disease enabled remedial measures to be adopted. The "Black-spot" or "Scab" of the apple, which was formerly regarded as "all weather," is now known to be caused by a parasitic fungus, which can be kept completely in check by spraying with Bordeaux mixture or lime-sulphur compounds.

It was natural that the minute and obscure micro-organisms, such as bacteria or microbes, should be studied later, and the bacterial diseases of plants are now fully recognised and are being successfully investigated.

But with the more extensive and intensive cultivation of the apple, and the greater attention that is being paid to everything which affects the quality of the fruit produced, certain obscure diseases are cropping up and coming into prominence, which are due neither to insects nor to fungi, nor even to the ubiquitous bacteria.

Such is the "Bitter Pit" of the apple and pear, which was only so named as recently as 1895, but, like many other diseases of plants and animals, existed long before that date, under various other names. The success already achieved in connexion with the treatment of plant diseases encourages us to hope that even such well-marked diseases of unknown origin as Bitter Pit, when thoroughly investigated, may become amenable to treatment. The necessity of checking, if

possible, the ravages of the disease, which appears not only in the fruit on the tree, but may also develop in transit, becomes greater every year as new orchards are established and the fruit export trade expanded.

As showing how rapidly the cultivation of the apple is being extended in the different States of the Commonwealth, and how a large export trade is being built up, I will give some figures relating thereto, kindly supplied by the Commonwealth Statistician :—

Table I.—Production of Apples in the Commonwealth for the past Three Seasons.

——	Queensland.	New South Wales.	Victoria.	South Australia.	West Australia.	Tasmania.	Totals.
	bushels.	bushels.	bushels.	bushels.	bushels.	bushels.	bushels.
1908–9	31,121	385,649	1,241,826	398,812	186,321	1,070,546	3,314,275
1909–10	29,662	474,838	1,121,702	557,130	217,533	1,480,107	3,880,972
1910–11	25,410	596,561	1,667,271	476,904	261,563	1,347,952	4,375,661
Totals	86,193	1,457,048	4,030,799	1,432,846	665,417	3,898,605	11,570,908

For the season 1910–11, the total production of apples in the Commonwealth was 4,375,661 bushels, on the basis of 40 lbs. to the bushel, showing an increase over the previous season of nearly half-a-million bushels, and for the three seasons ending with 1911, there was a grand total of 11,570,908 bushels produced.

Table II.—Oversea Export of Australian Apples from the Commonwealth for the past Three Years.

——	Queensland.	New South Wales.	Victoria.	South Australia.	West Australia.	Tasmania.	Totals.
	bushels.	bushels.	bushels.	bushels.	bushels.	bushels.	bushels.
1909	88	14,315	214,902	62,925	1,645	449,035	742,910
1910	70	27,820	188,233	141,002	6,657	702,630	1,066,412
1911	58	20,962	304,002	63,527	17,535	957,725	1,363,809
Totals	216	63,097	707,137	267,454	25,837	2,109,390	3,173,131

Confining our attention to the oversea export trade, and omitting all reference to the large Inter-State trade, there were 1,363,809 bushels exported during the year 1911, and this shows an increase of nearly 300,000 bushels over 1910, and of about 621,000 bushels over 1909. The total oversea export trade has thus reached such dimensions that the production is only about three and two-third times that of its bulk. With the large number of new orchards being planted and coming into bearing in the various States, there is bound to be a great increase in production, and while new markets are being opened up the quality of the fruit must be maintained.

The problem set before me in the investigation of Bitter Pit is a very definite one—to determine the cause and devise a remedy, if possible ; and, although in theory the cause has to be determined first, in order that the way may be prepared for a reasonable means of prevention or mitigation, yet in practice the measures adopted to reduce or minimize the disease will also help to throw light upon the factors concerned in its causation.

Hence, even from the outset, not only are there investigations in the laboratory to discover the true nature of the part of the plant affected, viz., the fruit, and the characteristics of the disease to which it is subject, but there are also systematic observations and experiments in the orchard to determine the contributing factors, either in the way of lessening or aggravating the disease. The

details of these observations and experiments will now be given, and their bearing shown on the cause of Bitter Pit and the direction in which a remedy is likely to be found ; for it must never be forgotten that the final test of the results obtained must be their actual value to the practical man.

II.—ORIGIN OF THE INVESTIGATION.

In the early nineties fruit-growers were beginning to get alarmed at the prevalence and spread of an obscure and mysterious disease in apples, which rendered the fruit unsaleable, often appearing while the fruit was still on the tree in the form of brown pits or depressions, but sometimes becoming visible only in store. Since this was such a serious menace, particularly to the export trade, the fruit-growers in some of the States took action, and the New South Wales Pomological Committee requested Dr. Cobb (16)* to undertake an investigation into the nature and cause of the disease, which he named " Bitter Pit " in 1895. The disease was said to be spreading rapidly and destroying an enormous quantity of fruit, and in the report submitted by Dr. Cobb the following statements were made among others :—

1. I am now of the opinion that the insect *Dyndimus versicolor* (Harlequin bug) is not the cause of this disease.
2. I have seen no evidence that would prove the disease to be caused by a fungus.
3. No remedy can be proposed beyond avoidance of the sorts liable to the disease.

In the State of Victoria, I also took the matter in hand, as far as other official duties would permit, but it soon became evident that the problem was one requiring undivided attention for at least some time.

Since this disease was common to all the States, the investigation of it was a national concern, and at the National Fruit-growers' Conference of Australasia, held in Melbourne in October, 1908, a motion was carried and laid before the Acting-Minister for Customs—" That this Conference, in view of the heavy losses resulting from Bitter Pit and other obscure diseases of fruit, earnestly recommends the Commonwealth authorities to take steps to bring about an exhaustive enquiry into the cause and the means of prevention of such diseases."

The matter did not escape the attention of the various Ministers of Agriculture, as at their Second Inter-State Conference, held in Melbourne in August, 1909, it was resolved, " That all the States co-operate in a series of investigations, with a view to ascertaining the origin, nature, and preventive (or curative) means of dealing with Bitter Pit.

Also that similar co-operative work be undertaken in regard to other diseases of plants and animals."

The fruit-growers, in conference assembled, also felt that something should be done, and at the National Fruit-growers' Conference of Australasia, held in Perth in October, 1909, when representatives were present from all the States of Australia, as well as New Zealand, a motion was unanimously carried :—" That the prevalence of Bitter Pit be brought under the notice of the Ministers of Agriculture, with a view to the appointment of a Board by each of the States interested, to consist of two practical growers and one scientist to report observations."

Investigations were still being conducted in a haphazard way in some of the States, but the Ministers of Agriculture were in communication on the subject, and the final outcome was that the Minister of Agriculture for South Australia, in order to proceed with the matter, obtained the views of the Ministers of Agriculture on this point, among others—Should the Federal Government be asked to contribute a portion of the cost ?

* The figures in brackets refer to the Literature at the end.

Since there was some difference of opinion among the Ministers, as to whether the States should undertake the work without seeking the co-operation of the Commonwealth Government, it was suggested by the Minister of Agriculture for South Australia that the following proposal should be discussed at the proposed Conference of Ministers of Agriculture, in Melbourne :—" The Commonwealth Government to be asked to contribute half the cost, the States of Victoria, Tasmania, New South Wales, Western Australia, and South Australia contributing the other half."

Meanwhile the National Fruit-growers' Conference of Australasia held in Hobart in December, 1910, adopted a resolution as follows :—" That this Conference, representing the fruit-growers of Australia, again affirms the desirability of the Commonwealth Government retaining the services of Mr. D. McAlpine, Victorian Government Pathologist, for the purpose of investigating the causes of and remedy for Bitter Pit."

Relative to the proposed investigation into Bitter Pit in Apples, the Federal Government affirmed a principle which may have far-reaching effects in dealing with other serious and obscure diseases of plants and animals, and which brings Australia into line with the up-to-date methods of the United States. The Acting Prime Minister writes :—" In view of the very grave importance of this subject, and the injurious influence of the disease in question on the fruit-growing industry—an industry which promises almost unlimited expansion, with profit and advantage to Australia—this Government considers it may properly extend financial aid to the States in meeting the cost of careful investigation, which may result in the discovery of a remedy for, and perhaps eradication of, this disease."

" It has therefore been decided to contribute at the rate of a sum not exceeding £1,000 per annum, *i.e.*, half of the actual expenditure, for a period not exceeding four years, upon the understanding that this arrangement will terminate at any earlier period, upon three months' notice, if the Supervising Committee is of opinion that investigation here or elsewhere has satisfactorily disclosed an efficient remedy for the disease."

It was ultimately decided that I should undertake the investigation of Bitter Pit, commencing on 1st August, 1911. The Commonwealth and the States combined have thus taken a forward step in enabling the investigator to devote his whole time to the solution of such a puzzling problem, without associating it with other duties, which might probably interfere with the due carrying out of the necessary laboratory and orchard experiments, and the proper study of the question in its scientific and economic aspects.

III.—HISTORICAL.

The first distinct notice I can find of this disease in Australian literature occurs in Frazer S. Crawford's (23) " Report on the Fusicladiums, &c.," published in 1886. Under the heading of " Miscellaneous Diseases, &c., affecting the Apple," there is one referred to as *Spotted Apples*, and the description is so precise that there is no difficulty in recognising the obscure disease afterwards named Bitter Pit by Dr. Cobb. The account of it is given in full on account of its importance. " For several years I have received apples from various parts of the colony covered with slightly depressed, roundish spots or pits, about one-eighth of an inch in diameter. In most cases the colour of the spots was normal, but in one case the spots were brown. Beneath the pits the fruit was coloured brown for some distance towards the core, but gradually lessening in width, until the altered part disappeared. This part, although decayed in one sense, did not cause the adjacent parts to rot, as in ordinary vegetable decay. Although it seems natural to suppose that the diseased spots are of fungus origin, yet I could not detect with the microscope any mycelium permeating the tissues. One fruit-grower asserts that the disease is owing to the trees being young and making too much sap when planted in a damp situation. Sir R. D. Ross kindly referred the matter to Mr. Mundy, his

manager, at Highercombe, who reports that "the spots on apples run thus—*Downton Nonpareil*, *Old Nonpareil*, *Pennington Seedling*, *Dutch Mignonne*, and *Lord Nelson* are subject to spots when a short crop, such spots as those I have noticed since first having to do with fruit ; they appear more plainly after the fruit has been stored for a few weeks ; also, when there is a large crop, some of the larger apples will be spotted and the smaller ones not, from the same tree. As the flavour of the apple is not altered, I therefore think it must be the nature of the fruit."

In Germany the disease is very common and well-known to the orchardist under the name of "Stippen" (pitting) of the apple. There is a spotting of the apple mentioned by Fries in 1819, which arises in the living fruit, and the cause is referred to a doubtful fungus (*Spilocaea pomi* Fr.), but since the fungus origin of the disease in question has been disproved, this cannot be accepted as a case of Bitter Pit.

The first distinct reference to it is given by Jaeger (41) in 1869, who considered the cause of it to be placing early maturing fruit too soon in a damp cellar, without keeping it for some time in a comparatively dry atmosphere.

In the United States it is commonly referred to as "Baldwin Fruit-spot," because that is the variety particularly subject to it, and the earliest mention of it is in 1891, when L. R. Jones (42) referred to it in the annual report of the Vermont Agricultural Experiment Station, as being quite common throughout the State. His description leaves no doubt as to the disease :—"The flesh underneath the spot showed brown discoloration for one-eighth inch or more in depth, and this discoloured portion was quite bitter to the taste"—and although a saprophytic fungus was found on the spots when the diseased apples were kept in a moist chamber, yet a re-examination of the brown spots showed that the spotting was not caused by a fungus.

In Canada it was described in 1896 by Craig (22) as "A Dry Rot of Apples," and the description with accompanying illustration prove its identity.

In South Africa it is mentioned by Lounsbury in a letter to me as being bad in the Hex River Valley in 1901 ; and Pole Evans (31) states that "Bitter Pit occurs practically wherever apple culture is carried on."

In India the disease has not hitherto been observed, and Dr. Butler informs me by letter that, after having examined hundreds of trees in Kashmir, where the fruit is extensively grown, he concludes that "the disease is, at any rate, not common in the apple-growing districts of Northern India."

In Russia it is recorded in 1910 by Diakonoff (27) that apples in store were badly affected with "stippigkeit," and, while quite free on picking, they were very soon covered with brown spots, and rendered worthless.

The earliest modern notice I can find of this disease in England is contained in the *Gardener's Chronicle* for September, 1905, where it is named "Apple Brown Spot" ; and it is further stated that this is not the first time it has been observed in Britain.

In France it was noted by Delacroix (25) in 1908 under the name of "Points brun de la chair de pommes," and is said to be common on numerous varieties of apples.

It also occurs in every State of the Commonwealth, and in New Zealand it was recorded by Kirk (45) in 1898 as occurring in the Wellington Province.

Bitter Pit being one of the obscure diseases of the apple, it is not likely to have attracted general attention before it became very pronounced, and from the very nature of the disease it would only be put on record, if at all, when it interfered with the profits of the commercial orchardist. But there are stray references to it scattered through the literature relating to the apple, and there is one aspect of the question which makes it highly probable that references to it may be overlooked, viz., that it only received the definite name by which it is now known as late as 1895.

Dr. Cameron, Director of Agriculture, puts this view of the matter very pithily when he writes :—"The dependence apparently placed upon the period (about 1891) when the disease began

to be much written about, as proving that it first occurred synchronously with the general adoption of spraying for Codlin moth, is weak if judged by parallels. It would scarcely be contended that appendicitis in man or actinomycosis in cattle did not exist until they came to be written about as such. Apart from the evidence of observant fruit-growers still living, the bibliography of the subject affords ample evidence of the existence of the disease before the name Bitter Pit was applied to it." In fact, when the new light which is thrown on the structure of the apple and given in a subsequent portion of this report, is taken into account, there are good grounds for believing that this disease may have existed in the apple from the time when it began to be generally cultivated.

The cultivated apple is a very ancient fruit, for De Candolle, in his "Origin of Cultivated Plants," after reviewing the evidence, concludes—"From all these facts I consider the apple to have existed in Europe, both wild and cultivated, from prehistoric times"; and Darwin, in his "Variation of Animals and Plants under Domestication," not only points out that this fruit occurs in the Swiss-lake dwellings, but that slight differences of culture and climate may produce important modifications. It is well known that American varieties of the apple produce in their native land magnificent and brightly-coloured fruit, but these in England are of poor quality and a dull colour. I do not therefore attach much importance to the statement, especially when important deductions are drawn from it, that the disease has only been known in comparatively recent times.

IV.—CHARACTERISTICS OF BITTER PIT.

To any orchardist who is familiar with this disease, and has suffered loss through it, its general characters are too well known to require description, but since there are various appearances mistaken for it, and other diseases associated with it, a clear description of its nature and characteristics will show exactly what we are dealing with in this investigation. It is often stated that it is not a disease at all, and if it were due to local poisoning, as is sometimes asserted, then in the strict sense of the term, the point might be conceded, but, as will afterwards be shown, this is one of the appearances mistaken for it. But even those orchardists who recognise the true nature of the trouble, sometimes deny that it is a disease. As one puts it, it is neither contagious nor infectious, and, therefore, not a disease. But this is simply applying a meaning to the term disease which is not generally accepted. A disease, in the ordinary acceptation of the term, is an abnormal condition of the organ, interfering with the use for which it is intended, or threatening its life, in whole or in part. It is a derangement of function, associated with corresponding changes in structure, and this will be clearly understood when we come to consider the normal structure and functions of the apple. From this point of view, it is a disease, and will be so considered here.

NAMES GIVEN TO THE DISEASE.

The name of Bitter Pit, which is the one now generally recognised in Australia, was first applied to this disease in 1895 by Dr. Cobb (16), then Vegetable Pathologist to the Department of Agriculture in New South Wales. He noted an obscure disease of the apple in 1892, which was characterized by pits or depressions externally, and brown spots in the flesh, with a bitter taste.

This was by no means the first appearance of the disease even in Australia, for in 1886 it was fully described by Frazer S. Crawford (23) in South Australia, under the name of "Spotting of Apples." It is generally known in the United States as "Baldwin Fruit-spot," because this variety of apple is specially subject to it, but it was described in 1898 by Maynard (56) as the "Dry-rot Spots" under the skin, in 1899 by Jones (43) as the "Brown Spot," and in 1908 by Brooks (9) as the "Fruit Pit."

In Canada it was described in 1896 by Craig (22) as a "Dry Rot" of apples, and in England, in the *Gardeners' Chronicle* of 1905, as "Apple Brown Spot." It seems to have been recognised in Germany even as early as 1869, where it is known under the names of "Stippen," "Stippflecke," and "Stippigwerden," indicating the pitting or stippling characteristic of the disease.

In France it is known under the names of "Points bruns de la chair" (brown spots of the flesh), and "Liége" (cork disease), with reference to the cork-like nature of the cells.

The spotting of the fruit was no doubt frequently noticed by the orchardist, without being considered definite enough and of sufficient importance to be recorded, and such local names were applied as "measles" and "small-pox."

NAKED-EYE CHARACTERS.

This is a disease of "pip" fruits, such as apple, pear, and quince, but for our present purpose, the description will be confined to the apple. As the name indicates, there are usually pits or depressions on the skin, and these hollows on the outside represent a corresponding shrivelling or shrinking of the tissue inside. These depressions are numerous, and mostly on the upper half of the apple. They may be confined to one side, or extend all round, and sometimes reach to within an inch or so of the stalk. There is always a small area surrounding the stalk free from the "pits." (Frontispiece.) They vary in size from mere dots up to one-eighth of an inch in diameter, but they may run into one another, and form larger depressions. They are generally roundish in outline, and the colour varies from a pale to a dark green, but on the same apple they may assume a ruddy brown or a dark brown tint. The outside appearance, however, is very variable, according to the stage of the disease. There may be no external indication whatever, and it is only when you begin to eat the apple, and find it bitter to the taste, and with brown spots through it, that you realize the presence of bitter pit. But, as a rule, there are surface indications. There may be just the slightest sign of an indentation, with no change in the colour of the skin, or there may be a regular depression, with the skin there of a deeper green, then they may become of a pale or dark-brown colour, until almost the entire surface of the apple is covered with them. When a transverse section is made, internal brown spots may occur all round, generally beneath the skin, with occasional spots scattered through the flesh, even reaching to the boundary of the core. These spots are at first of a pale brown, and gradually turn a darker brown. This brown tissue is generally dry, and of a loose and spongy texture, as if honeycombed. The brown streaks in the flesh not connected with the surface pits are associated with the fibro-vascular bundles. (Plates I. and II.)

MICROSCOPIC CHARACTERS OF THE BROWN SPOTS.

These are the naked-eye characters of this disease, but if sections of the brown spots are examined under the microscope, the cells are seen to be collapsed, with their walls toughened, and if observed when the fruit is ripe, and the starch has been converted into sugar, the dead brown cells contain numerous starch-granules. (Figs. 24, 25.) Of course, at an earlier stage, both diseased and healthy cells contain starch. A peculiarity of this disease is that the fruit may not show any external sign while still on the tree, but only after it has been in store for a longer or shorter period. However, with us its development is common while the fruit is still attached to the tree, and I have seen over 90 per cent. of the Prince Bismarck variety of apples badly affected on the trees.

The browning of the tissue has to be explained, as well as the large cavities in it, while the surrounding healthy pulp is white, and it is most important to determine the changes which have actually taken place. Thus, Sorauer (85) assumes that at the time when the fruit was swelling, the cell-walls of the brown tissue had already become *corky*, and, being incapable of further expansion, the cavities in the tissue thus arose. But, as we shall see immediately, there is no evidence of corky cell-walls.

If a thin transverse section of a pitted apple is taken about the equator, and stained with various re-agents, the reactions of the different tissues or portions of them are shown.

(*a*) Chlor-zinc-iodine, or Schulze's Solution, stains the *starch-grains* blue, and it is observed that the blue colour first appears around the ten fibro-vascular bundles, and gradually extends outwards in a radiating manner, so that there are ten radiating blue bands extending from the boundary of the core, indicating the presence of starch. There are blue patches, more or less irregularly, through the flesh, and some very deep blue lines immediately beneath the skin. The brown spots in the pulp also contain starch, and are stained, but the brown colour of the walls masks it somewhat.

(*b*) Phloroglucin, with hydrochloric acid added, stains the *lignified* or woody tissue a rose-pink or even crimson, and the sections show the walls of the seed-vessels, a circle of five dots at the very centre, and any portions of the fibro-vascular bundles a beautiful pink colour. The brown spots only show traces of pink, where a portion of a fibro-vascular bundle is present, and there is no lignification of the brown walls. Aniline sulphate has the same effect, only it stains the lignified parts a bright canary yellow.

(*c*) A freshly-prepared and concentrated solution of chlorophyll was also used to stain a section. After being kept in the dark for some time, a microscopic examination showed no deep-green staining of the brown cell-walls, indicating that the walls are not corky. Sections of cork treated at the same time showed the cell-wall coloured a distinct dark-green.

Thus, there is no evidence of the walls being lignified or corky, and the gummy or mucilaginous substance which colours them brown is of a pectic character.

When a ripe apple is selected, affected with Bitter Pit, the healthy cells are free from starch, since it has all been transformed into sugar in the process of ripening. But the cells constituting the brown spots contain numerous starch-grains, because the browning, and consequent death of the tissue had occurred before the final stage of ripening had been reached. This is very evident on examining a section of a brown spot under the microscope. While the round or polygonal healthy cells of the pulp are regularly arranged and firm, those of the brown tissue are very irregular in outline, and the starch-grains are enclosed within their walls. (Fig. 25.) They are collapsed and broken down, the walls often lying flat against each other, and the starch-grains tucked in between them. After a careful examination of numerous sections, from different varieties of apples affected with Bitter Pit, I always found the discoloured tissue to consist of broken-down cells, still retaining their starch-grains. There were also discoloured fibro-vascular bundles in the vicinity, and more or less numerous cavities, as shown in Figs. 26 (*a*) and (*b*). When the pitted apples were unripe, starch-grains occurred in the normal tissue as well as in the brown collapsed cells. It is an important point to settle whether the dead cells have burst, owing to too great internal pressure, or have collapsed from the failure of their water supply.

It is not an easy matter to determine from a microscopic section, whether the cells have burst or collapsed, since in the very act of making the section a certain amount of rupturing has occurred, but their capacity for absorbing water will show whether it is a case of wilting or bursting. The bursting of the individual cells from within is not likely, since each originally balloon-like cell would be a buttress to its neighbour, and the whole would form a rigid body. However, a section of a portion of a brown spot was made, and mounted at once, and photographed. (Fig. 28.) This shows the collapsed cells, and large cavities scattered through the section. A section of the same spot, in sequence, was made, and allowed to remain in water for 40 hours before photographing. (Fig. 29.) The collapsed cells have evidently absorbed moisture and become distended, showing that bursting had not taken place. This internal browning of the flesh of the apple may be brought

about in various ways, by bruising the skin without breaking it, by hail, and other agencies, as will be shown later, but the recognised Bitter Pit is due to internal causes, to be afterwards explained. The bitter taste of the affected fruit has been called in question, but, while it is generally perceptible, it is not always to be detected, just as in the case of bitter rot. I find that it requires to be kept in the mouth for some little time before the bitterness is perceived. Besides, the sense of taste is much keener in some individuals than in others, and the remarks of Dr. Cobb, who gave it the name of Bitter Pit, are pertinent. "I recently had a vote taken among some impartial persons, and the result was decidedly in favour of the bitterness of the pits. It may be that two or more diseases are spoken of under this head, and that this accounts for conflicting opinions. The taste, to me, is decidedly bitter. People differ in what they call bitter. Users of tobacco and spirits sometimes have an altered taste."

The rotting of the fruit affected with Bitter Pit is also characteristic. The apple, as a whole, becomes brown, the pulp turning soft, and, although shrivelled and shrunken, there is no breaking of the skin. It may finally be noted that trees subject to this disease may be perfectly healthy otherwise. The Prince Bismarck tree shown in Fig. 133 was badly pitted, but it looked perfectly healthy as a tree, and even when the roots were carefully examined, there was no sign of weakness.

V.—CONFLUENT BITTER PIT OR CRINKLE.

This is a disease which has been particularly prevalent during the past season, and to which I gave the name of Crinkle in 1901, in a Report on Diseased Apples (57), and the short account there given may be reproduced here.

"Besides the recognised Bitter pit, which causes small brown depressions on the surface, another appearance was noticed, particularly in Rome Beauty and Five Crown Pippin. The skin is apparently quite sound but a little darker towards the eye end, and, if cut across, brown dead tissue is found immediately beneath the skin or beneath the skin and the core. There may be actual cavities in the decaying flesh, and the diseased patches do not taste bitter (?) Although many varieties not specially subject to Bitter pit exhibit the Crinkle disease, it is probably likewise due to disordered nutrition. The upper end of the apple ripens first, and if from any cause a proper supply of nourishment fails to reach it, there would be decay and ultimate death of the cells. I have given the common name of "Crinkle" to this disorder because the upper surface of the fruit is thrown into rough folds, giving it usually an uneven and crinkled appearance. Crinkle appears to be most common in the cooler districts, the worst affected varieties in South Gippsland being Five Crown, Rome Beauty, and Rymer, while Jonathan, Prince Alfred, and Esopus Spitzenberg are not susceptible."

Since then, numerous specimens of the disease have come under my notice, and I have been able to investigate it more fully, both in the orchard and in the laboratory. It generally occurs towards the crown end of the apple (Figs. 30, 39), and when a transverse section is made there, as shown in Fig. 38, the tissue beneath the skin is seen to be brown and spongy, with large cavities through it, while the skin itself remains intact. This brown tissue is more or less continuous, and not in isolated patches as in ordinary Bitter pit. I now find, however, that on the same tree there may be every gradation from Bitter pit alone to Bitter pit and Crinkle combined, and finally Crinkle alone. On a Blenheim Pippin tree at Burnley Gardens, a solitary apple was affected with Crinkle, while the bulk of the crop had Bitter pit, and on another tree of the Five Crown variety in the suburbs of Melbourne with a fairly good crop, a single apple was affected with Bitter pit, while a majority of the others had Crinkle or Crinkle and Bitter pit combined. When the disease is not

far advanced, it may present the appearance of pimples rather than dimples, and this is easily explained. The shrinking of the tissue beneath the skin in isolated patches causes pit-like depressions, but when the patches become continuous, the wave of depression has a corresponding elevation, and, when it extends over a considerable area, then it is thrown into folds and wrinkles.

An examination of a large number of affected trees in different districts showed that it is not confined to one side of the tree, but occurs all round it; that it may occur equally in those fruits exposed to the sun and those in the shade, that the topmost boughs may bear apples free from it or they may be affected; and there is every gradation to be found, even on the same tree, of pit, pit and crinkle combined, and crinkle alone.

It may be found associated with other diseases, such as "water core" or "glassiness," and during the past season sun burn or heat scald has frequently accompanied it. So much has this been the case that the disease has been attributed to that cause, although, that the two are distinct, may be seen occasionally when one side of an apple is affected with sunburn and the opposite with crinkle. An apple affected with crinkle is an easier prey to excessive heat than a sound one, and in every case of crinkle the skin is unaffected, whereas in sunburn, acting from the outside, the skin suffers. It only remains to add that when the brown tissue of crinkle is kept in the mouth for some time there is a decided bitter taste. In Tasmania, the disease is usually called "Pig-face," because it disfigures and gives a peculiar appearance to the crown end of the apple when badly developed, and a grower referred to the affected apples as "tuberculous" from the pimpled nature of the surface. It is, likewise, sometimes called "Monkey-face."

It also occurs in Five Crown apples in New South Wales, and, although known in certain districts for many years, the disease has never caused much loss.

The varieties in which it has actually been found in Victoria this season are—Five Crown or London Pippin, Newton Wonder, Blenheim Pippin, Stone Pippin, Annie Elizabeth, Jonathan, Statesman, and Baldwin. In South Australia it occurred in Five Crown, Rome Beauty, and Dunn's Seedling or Munroe's Favourite. As throwing light on the conditions under which this form of Bitter Pit occurs, I will give two illustrative examples. At Burnley Gardens, immediately after the fruit had set on an Annie Elizabeth apple-tree, a number of clusters were tied up in white calico bags to see the effect on the development of Bitter Pit (Fig. 111), but, on removing the fruit early in March, a little crinkle was found, five crinkled apples being in the bags, and only one of the apples exposed on the tree affected. There was this peculiarity about those occurring in the bags: that, while crinkle was very pronounced, dark-green depressions characteristic of Bitter Pit were associated with it, and sometimes found overlying it. Here both "pit" and "crinkle" had developed in the same apple, and, on making a section, the continuous brown tissue as well as the isolated patches were seen. Exposed apples also showed pit and crinkle combined, but it was very noticeable in the apples enclosed in the bags.

It may also be noted that, although the apples were protected to a certain extent from the effects of the sun's heat by the white bags, nevertheless a larger proportion were affected with crinkle than those exposed on the trees.

In an orchard at Healesville, Victoria, "Crinkle" was very bad this season, while last season it was not noticed. The variety was Five Crown or London Pippin, the trees were from 15 to 25 years old, and out of 2,000 cases of fruit, less than 1,000 were sound. This loss was entirely due to "Crinkle," and it was first observed on 19th January. Afterwards it developed very rapidly and in about a fortnight it was quite general. In the same orchard there was a luxuriant crop of Jonathans, but not a trace of Crinkle could be seen on any of them. The conditions otherwise being equal, there was evidently something in the constitution of the Five Crown apples which rendered them peculiarly susceptible to this disease.

Apples exposed to the direct rays of the sun were equally affected with those in the shade, but it was observed that apples towards the topmost boughs were generally free from it. Frequently, in two adjoining apples, one was free and the other affected, and sometimes the larger, sometimes the smaller was perfectly sound. It was observed that four trees sheltered by a building from the north wind were remarkably free from it, and the roots on the same side passed into made up soil. This would tend to keep the roots cooler, and prevent the pumping action during the night when the fruits would not be so actively transpiring as during the day.

This district has a heavy rainfall, and last year it reached 52·77 inches. If we compare the rainfall of the first two months of 1911 and 1912, it is as follows:—

	1911.		1912.
January	1·85	..	1·16
February	7·08	..	1·31

In December, 1911, the rainfall was 5 inches, and this would influence the growth during the succeeding month when "Crinkle" developed. I have no means of getting the rainfall for December, 1910, preceding the year in which Crinkle was practically absent, because no records were kept. A comparison would be interesting, since the rainfall is very irregular, as shown by 7·08 inches in February, 1911, and only 1·31 inches for the same month in 1912.

Five Crown or London Pippin is undoubtedly very susceptible to "Crinkle," and the configuration of the apple may have something to do with it. It is called the Five Crown from the circumstance that there are five ribs on the sides, which increase in size towards the crown, and there form five prominent ridges. There are thus very decided ridges and furrows, and it will be shown subsequently that wherever there is irregularity of growth the conditions are favorable for the development of Bitter Pit, and consequently of Confluent Bitter Pit or Crinkle.

In New South Wales, the Fruit Expert states that Five Crown apples were affected, and that it has always been found to be worse on light poor soils and in very dry seasons. But it also occurred in the Bacchus Marsh district of Victoria, where irrigation is practised, and there is plenty of moisture. Like Bitter Pit, therefore, it may occur in wet or dry seasons.

SYMPTOMS.

There is no mistaking the "Crinkle" or "Pig-face" when it is fully developed. The crown end of the apple is usually thrown into very irregular folds, and the prominent ridges sometimes stand out so that it is suggestive of a pig's face.

There may be only a slight irregularity towards one side of the crown, or it may sometimes be deeply sunken but still firm. It may be on the shady or on the sunny and coloured side of the apple, and sometimes the irregularity extends towards the base. When it is combined with "glassiness" (Fig. 44), then it may become quite soft, and it may be further disguised by sunburn, but, when a section is made through the crinkled portion, then the appearance is very characteristic. The green skin is quite intact, but immediately beneath it there is a more or less interrupted ring of brown tissue, with large cavities here and there owing to the rupture of the tissue. When a longitudinal section is made, it may be found to be confined to the crown end, or it may extend almost to the stalk.

There is sometimes confusion over this disease owing to the fact that it is often associated both with "glassiness" and "sunburn." In glassiness, the tissue is not discoloured, and it is firm, and in sunburn or heat scald the skin is affected. Sometimes there is sunburn on the coloured side of the apple, and crinkle on the opposite side, showing that the sun did not act upon it directly. Occasionally, it occurred in a Jonathan apple coloured all over, and without any external sign except that it was slightly mis-shapen on the side affected with Crinkle.

In this, as in other diseases, it is customary for the average orchardist to observe only external appearances, and not go beneath the surface for an explanation. But conclusive proof is given of the internal origin of the disease when an affected apple is cut across, and the continuous brown spongy line is seen beneath the green skin which is perfectly formed on the outside (Figs. 33, 36, 38).

The only reference I can find to this disease elsewhere than in Australia is by R. E. Smith (82) in California, where it is described and figured under the name of the "Hollow Apple."

"A peculiar condition found in one or two instances. The affected fruit is sunken in on one side, and has a mis-shapen appearance. On cutting through the apple, large hollow cavities are found, corresponding to the sunken areas on the surface, due apparently to some injury while the fruit was small."

CHEMICAL DIFFERENCES BETWEEN SOUND AND CRINKLED.

In order to test the chemical difference, if any, between the crinkled and sound from the same tree, specimens of Five Crown and Annie Elizabeth were submitted to Mr. Scott, the Agricultural Chemist. The apples chosen were as nearly as possible of the same size and generally similar. The following is the result:—

Table III.—Analysis of Clean and Crinkled Apples.

—	"Five Crown" (Healesville).		"Annie Elizabeth" (Burnley Gardens).	
	Clean.	Crinkled.	Clean.	Crinkled.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	83·81	83·06	84·33	85·06
Acidity (as Malic Acid)	·576	·576	·858	·610
Total Sugar—percentage of juice (as dextrose) ..	12·50	13·41	11·28	10·99

The amount of moisture, the acidity, and the total sugar contents were the points chosen for comparison. As regards moisture, chemical analysis showed less in the crinkled Five Crown and more in the Annie Elizabeth apple. In acidity, there was practically no difference, although in the Annie Elizabeth there was slightly less; and, as regards total sugar, there was a little more in the Five Crowns and a little less in the Annie Elizabeth apples. So that no general conclusions can be drawn from the results, although it would have been more satisfactory to have analyzed only the crinkled tissue and not the entire apple for comparison.

VI.—AN "OBSCURE DISEASE" OF THE APPLE.

In 1892, Dr. Cobb (15), then Vegetable Pathologist to the Department of Agriculture, New South Wales, referred to an "obscure disease" which rendered the apples worthless. They were of irregular growth, hard, and often bitter. Then, again, in 1897 (17), he referred to it under the heading of "Cause of an important Apple Disease," and attributed it to the woolly aphis. He found this insect on the apples, and sometimes a few in the passage leading to the core, and he came to the conclusion that just as they cause unsightly malformations on the roots and limbs, so may they affect the fruit and cause this deformity. The woolly aphis is often found on the apple,

however, without producing any such results, and the matter was left in a state of uncertainty. "I hope this note may lead to the solution of this mysterious and so-called 'obscure disease,' which, it will be seen, is one of considerable importance."

Visiting the district of Orange in 1912, from which these apples were originally obtained, I found the same disease in various orchards, and Fig. 45 shows twenty specimens of these deformed apples taken from one tree. It was confined to one variety, Pomme de Neige, and, curiously enough, this sort is blight-proof, or nearly so.

Fortunately the Orchard Inspector for the district sent me a specimen of Pomme de Neige on 30th November, when the fruit was about the size of walnuts, and it was the earliest sample for the season of what looked like Bitter Pit, even although I was carefully watching for the earliest trace of it in the Burnley Horticultural Gardens. It was photographed in section (Fig. 47), and showed the brown spongy patches at the core as well as beneath the skin.

This "obscure disease" started at an early stage in the growth of the apple when the "core" formed the bulk of it, for the flesh is merely a thin layer around it at first, as shown in Fig. 74. If the conditions were favorable to the development of "pit" at this stage, it would naturally surround and even encroach upon the core, and, as the apple continued to grow, more brown spots would be developed beneath the skin, and thus they would extend from core to circumference. At this early and tender stage, the brown spots practically surrounded the core, and the depressions on the surface would be somewhat similar to that of "crinkle."

In fact, it is just a form of crinkle starting at an early stage in the growth of the apple, and causing the sunken and lumpy appearance. In the ordinary crinkle, as in ordinary Bitter Pit, the injury is caused when the apple is comparatively advanced in growth, and it may grow beyond it, so that the brown patches are inward from the skin, as well as immediately beneath it. But in this instance the apples were actually stunted in their growth, and ceased growing on account of the early attack.

From the above consideration of "crinkle" and this "obscure disease" of the apple, it will be seen that they are just special forms of Bitter Pit. We have also seen that Bitter Pit may start at various stages in the growth of the apple, according to the nature of the variety and the conditions prevailing. In Early Red Margaret for instance, Bitter Pit was first observed this season on 4th December, when it was approaching maturity, but distinctly noticed on most varieties when half or three-quarters ripe. Crinkle was first observed in Five Crowns on 19th January, when about half ripe.

VII.—EFFECTS OF FROST ON THE APPLE.

It has been suggested that frost might cause this distortion and malformation, but, although there is outward distortion the internal appearances are quite distinct.

While visiting Harcourt, in Victoria, towards the end of March, I found that there had been a severe spring frost about the end of October, and, while a number of the apples had been completely destroyed, there were a number still on the trees. These, however, were variously twisted and deformed on the side exposed to the frost, and invariably that side was much reduced compared with the other. An extreme case is shown in Fig. 50, where the deformity was around the "eye" which was twisted round to the side, instead of being at the apex. When the frost is sufficiently severe to reach the core and cause the pips to turn prematurely brown, then there is no further growth of the apple; but when it does not penetrate sufficiently deep, the apple continues to grow.

Some Rymer apples affected with frost were carefully examined. A freezing of the calyx end shortly after the fruit had set caused the deformity, and they had afterwards grown almost to their full size, and many of them had taken on their natural colour. When a transverse section is made, streaks of brown tissue are seen in the flesh about a quarter of an inch beneath the skin on the affected side, and these are more sparingly distributed on the swollen side. Wherever these streaks occur, there is a sort of natural parting in the flesh, and when a small portion of the brown collapsed cells is examined microscopically, there are invariably found numerous tufts of the colorless hair-like structures afterwards referred to. The cells composing them still contain starch grains, as they are coloured blue by iodine, and they are quite similar to the cells of the flesh, only much smaller, and arranged in the form of filaments.

VIII.—"WOOLLY STRIPE" OF SEED VESSELS, AND A SIMILAR DEVELOPMENT IN THE FLESH OF THE APPLE.

When an apple is cut transversely about the middle, each of the five seed-vessels constituting the "core" is seen to have a cleft formed by the splitting of the carpels, and this is usually fringed with a white woolly substance. On examination under the microscope this is seen to consist of numerous colorless, jointed, wavy, branched filaments, the cells of which are cylindrical in shape, the terminal cells rounded at the apex, and the cell-walls finely warted. They occur where the rupture has taken place, and the outgrowths are the result of it.

Not only are these branching filamentous structures found in the clefts of the carpels, but the inner face of the firm cartilaginous wall bounding the seed cavity has often definite streaks or bands of the same filamentous structures projecting into the cavity, and these stripes have been named by Sorauer (85) from their characteristic appearance "Woolly Stripes" (Wollstreifen). The inner wall itself is composed of more or less elongated, thick-walled cells, with numerous pore-canals, and underlying that are layers of polygonal thick-walled cells which pass into ordinary parenchymatous tissue (Fig. 52). This structure evidently gives the necessary firmness to the walls of the seed vessels, and at the same time acts as a protection against the entrance of fungi, which might reach the cavity in those cases where there is a hollow space leading from the "eye" end of the apple.

Sorauer considers, and justly so, that where the woolly stripes occur, this protection against fungi reaching the flesh no longer exists, since the woolly hair-like structures gradually pass into the cells of the flesh (Fig. 52). He concludes, therefore, that at the time when the greatest swelling of the fruit takes place, such a tension is produced in the cells by the sudden absorption of relatively large quantities of water, that the cartilaginous wall is ruptured along the lines corresponding to the stripes and the inner thin-walled cells, relieved from the pressure, grow out into the cavity in the form of elongated jointed filaments. Here, again, the filamentous structures are produced as the result of rupture. But these self-same structures are not confined to the seed-vessels, for they occur as well in the flesh of apples which have been bruised and those injured by hail or frost, and even in association with the brown patches of Bitter Pit.

A Yates apple was artificially bruised, and, in connexion with the broken, collapsed, and discolored tissue, there were numerous tufts of the filamentous cell-rows.

When the injury was produced by hail, and the skin either broken or unbroken, the same filamentous cell-rows were found associated with the bruised and discolored tissue. In apples struck by frost, the brown patches in the interior were surrounded by numerous tufts of filaments and even in the brown spots of Bitter Pit there was an occasional development in the adjoining cells of similar structures.

A summary of the occurrence of these filamentous structures in the apple will show how widely distributed they are—

(*a*) When an apple is cut across through the core, a white fluffy substance is seen at the sutures or seams where the ripe carpels split, and this consists of colorless, branching, warty, hair-like filaments, composed of cells containing starch.

(*b*) Very often, but not always, on the inner face of the cartilaginous walls of the seed-vessels, there are "woolly stripes," consisting of similar filaments, and arising from ruptures in the lines corresponding to the stripes (Fig. 51).

(*c*) When an apple has been struck by hail and the cells of the flesh beneath the skin have been ruptured and become brown, there the self-same filaments are to be found ramifying in the tissue.

(*d*) When an apple has been bruised artificially or otherwise, so that the pulp cells are ruptured, they become brown, and the filaments appear as before.

(*e*) When the frost affects an apple, particularly in the early stages of growth, there is a zone to which it reaches, and there is a kind of separation of the tissues where the frozen and sound portions meet. In that zone the cells become brown, forming an interrupted circle, and there is a luxuriant development of the filaments.

(*f*) In the brown spots of Bitter Pit, the same filaments are to be found where the cells have separated and formed cavities, but much more sparingly than in the former cases. As will afterwards be shown, there is not a bursting of the cells in Bitter Pit, but only collapse, so that the rupture mainly occurs where the cells are already dead, and it is only living cells which are capable of growing and giving rise to the filamentous structures.

(*g*) In the cavities formed by "crinkle" the hair-like filaments are also found, and they adjoin the brown cells as in other cases.

It will be observed that these filaments, composed of rows of delicate cells, only occur wherever there has been an internal rupture, and this rapid multiplication of thin-walled cells is evidently due to the irritation produced by the rupture. First of all we observe that the filamentous rows of cells arise from adjoining uninjured cells of the flesh, and Fig. 53*a* shows such a cell growing out into a filamentous structure.

Now, this rapid multiplication of cells is not unusual in plant tissues when they have been stimulated into activity by various agencies, such as insects or fungi, only it has not been specially noticed as arising from an internal rupture.

When a plant is wounded, it is well known that this acts as a stimulus to the rapid formation of cells, as, when the delicate cells of the cambium are cut with a knife, they respond by covering up the dead cells with a fresh and luxuriant growth. So in the case of an internal rupture or wound, the adjoining cells of the flesh are stimulated into renewed activity, and, instead of enlarging in the normal way, they produced numerous tufts of relatively small, thin-walled cells, assuming the form of a filament from their rapid growth. It has also to be noted that such cells contain starch-grains, which are coloured blue by iodine, and the terminal cell is usually filled with a finely granular protoplasm, resembling the apical growing cell of an ordinary filamentous structure.

It may be asked what has the development of these abnormal growths to do with Bitter Pit. Well, an ingenious suggestion has been communicated to me by Güssow, that these delicate cells found associated in some instances with the brown spots of Bitter Pit may break down and undergo decay, particularly when the apples are kept in store, and result in the production of brownish spots. The browning of the tissue is not always accompanied by these filamentous structures, and existed before their formation, so that they cannot be the general cause. But it is just possible

that they may contribute to the extension of the brown patches by their subsequent decay, especially under storage conditions, and this view receives support from the proved fact that, when apples are kept at a low temperature, such as 30–32° F., the development of Bitter Pit is retarded.

From the mode of origin of these filamentous hair-like structures, it is not surprising that the same appearances have been met with in other plants as well as the apple. Sorauer (85) found them, for instance, clothing interior cavities in turnip-tops and in the leaf parenchyma of "layered" oat-plants.

As these filaments are found so frequently accompanying brown spots in the tissues and ramifying luxuriantly in their vicinity, they might easily be mistaken for the hyphae of a fungus, and I have no doubt but the discovery of fungi in some instances as the cause of the "spotting" has been due to the appearance presented by these branching hypha-like structures (Fig. 53*b*).

VARIETIES WITH "WOOLLY STRIPE."

A number of different varieties were carefully examined for "Woolly Stripe," to see how far it was associated with Bitter Pit, but, while it was beautifully developed in Cleopatra (Fig. 51), there were other badly pitted varieties in which it did not occur.

It was found on the inner face of the seed-vessels in the following varieties:—

Annie Elizabeth.	Lady Henniker.
Baldwin.	Lane's Prince Albert.
Battalion.	Munroe's Favorite or Dunn's Seedling.
Cleopatra.	Rhode Island Greening.
Dillington Beauty.	Rome Beauty.
Esopus Spitzenberg.	Rymer.
Five Crown.	Stark.
Hartington Codlin.	Stewart's Seedling.

IX.—APPEARANCES MISTAKEN FOR BITTER PIT.

There are a number of fruit-spots which may be variously caused, and which have a superficial resemblance to Bitter Pit, but, from the symptoms already given, a careful observer should be able to discriminate between this disease and the various appearances likely to be mistaken for it.

There are certain associated diseases which are sometimes confounded with it, but these will be dealt with under a separate heading.

A few of those appearances which have actually been brought under my notice as cases of Bitter Pit will now be considered.

HAIL MARKS.

At the Burnley Gardens, specimens of a young seedling apple known as Borrowdale were brought under my notice as being "pitted." This variety is one of the largest and earliest apples grown there, and, since it is rather subject to Bitter Pit, the depressions on the surface were considered suspicious.

It was on the 25th October, 1911, when the apples were about the size of walnuts, that these markings were first observed, and the previous afternoon there had been a severe hailstorm at the Gardens. The pits or depressions were on the coloured and exposed surface of the fruit, and varied in size from a pin head to about one-eighth of an inch in diameter. They were generally irregularly

round, and in some instances the skin was cracked in the cavity. The skin had the appearance of being pushed in, and not of being shrunken as in Bitter Pit. When a transverse section was made through the depression, the tissue was seen to be browned beneath in the shape of a crescent. Under the microscope, the section showed the epidermis to be either entire or broken, but the hypodermal layer of cells was flattened and squashed. The browned cells of the flesh immediately beneath that were generally of their natural size and shape, and not collapsed as in the case of Bitter Pit.

On examining other varieties of apple, similar depressions were found, even on Yates, which is not liable to Bitter Pit, so that the evidence was all in favour of the hail having caused the markings. Besides, the depressions were clearly caused by a pushing in of the skin, and not a shrinking of it, as is so noticeable in Bitter Pit.

It does not necessarily follow that all the markings were freshly caused on the previous day, for on the 28th September, when the fruit had already set, there was also a hailstorm, which, although not noticed at the time, would affect the young and tender fruit. When the skin is unbroken the fruit will not show any evidence of the depressions later on, but if broken there will always be a mark left.

Hail-marks are generally indicated by being on one side of the fruit, by the skin being broken at least in some spots, and there are often elongated markings without any break, showing where the hail glanced off the skin.

BRUISED SKIN.

When a healthy apple is bruised without breaking the skin, such as making a slight depression in it, the pressure causes the cells beneath the skin to turn brown afterwards, and, on examining the brown tissue, the symptoms are found to be similar to those of Bitter Pit.

Lafar (47), in the English translation of his Technical Mycology in 1898, attributes the "brown spotting" of the apple, that is, the spotting of sound apples under the rind, to some mechanical action. Whenever the cells become ruptured, from the dropping of the apple from the tree or pressure in packing or transit for example, then the oxygen is afforded an opportunity to act on the exposed constituents of the plasma. The enzyme found in the apple by Lindet (107) in 1893 carries the oxygen to the tannin, and the result is that dark-coloured oxy-compounds are produced which are precipitated on the cell-walls as a permanent dye. This view explains the discolouration of the tissue, but does not account for the development of the brown spotting while the apple is still growing and attached to the tree, where external mechanical agencies are excluded from the very nature of the case.

Then, Stewart (88) in 1899 also observed the effect of the bruising, and found the bruised tissue loaded with starch, while the adjoining uninjured tissue was free from it. If the bruises were made before the ripening of the fruit, then the starch would not undergo any further change, since on the death of the cells their activities ceased and the transformation of starch into sugar was arrested. As the fruit ripened, the starch would disappear in the healthy cells, and hence the contrast between the contents of the injured and uninjured tissue. Varcollier (119) in 1904 observed that, while ripe apples contain little if any starch, bruised apples contained large amounts in the vicinity of the bruise. He investigated the cause of this, and came to the conclusion that the action of the tannin on the diastase prevents it from transforming the starch into soluble sugar. But the death of the cells, in my opinion, is quite sufficient to account for the persistence of the starch in the bruised cells.

Although an external bruise produces symptoms resembling those of Bitter Pit, yet, since the latter originates from within without any external pressure, there are various differences. When a green apple is artificially indented in the skin, without breaking it, a browning of the tissue beneath soon appears, and after repeated trials it was found to occur usually in twenty minutes.

When a thin section of such a bruised portion is made, the cells of the flesh are seen to be broken and collapsed, and of a yellowish-brown tint, but it is very noticeable that the adjoining fibro-vascular bundles are not generally discoloured as in Bitter Pit. In connexion with the discoloured cells, there are also tufts of filamentous colourless cell-rows, sometimes branched and usually projecting into the cavities produced. The browning likewise extends inwards from the epidermis, and this is another point of distinction from Bitter Pit, when there is an artificial bruising from the outside.

The Yates variety was chosen for these observations because it is not subject to Bitter Pit.

EFFECTS PRODUCED BY CHEMICAL RE-AGENTS.

It is stated by Wortmann (97) that if apples are punctured with a needle and placed in solutions of an alkaline or acid character, pitting is produced which cannot be distinguished from the natural product. There is only a superficial resemblance, and, although experiments were carried out with various reagents, such as lime water, potassium tartrate, chloroform, oxalic acid, &c., I will only give the results obtained in three cases, viz., citric acid, malic acid, and corrosive sublimate or mercuric chloride.

Citric Acid.—A 10 per cent. solution was used, and Jonathan apples, both punctured and unpunctured, were immersed in it on 6th July, and finally removed on 28th August, so that they were immersed for a period of 53 days. This solution produced a visible effect upon the skin (Fig. 57). The unpricked apple showed depressed spots most numerous about the equator, often round and sometimes confluent. These spots were not unlike those of Bitter Pit externally. In order to see if there was any deeper resemblance, a section was made, but this only showed the normal tissue beneath the skin, and there were no starch-grains visible in the cells of the flesh, even after treatment with iodine solution.

The pricked apple showed the punctures just as if freshly made (Fig. 57*a*), and on making a section the cavity was seen to be quite distinct, without any change in the flesh adjoining. The depressed spots were distinct from the punctures, and confined to the skin. Both apples had changed in colour to a reddish-yellow.

There was thus no production of Bitter Pit by means of this or the other reagents tried, and, even where the skin was affected, as in the case of citric acid, it was only superficial.

Malic Acid.—Pure crystals were used, and a 10 per cent. solution made. Mature Yates apples were kept in this solution for 24 hours, both pricked and unpricked, the puncturing being done with a sterilized needle.

In the unpricked apples there were round discoloured spots, very slightly depressed, about 3–4 mm. in diameter, and, when cut through, the tissue for a short distance beneath the skin was pale-pinkish and assumed a crescent shape corresponding to the external spot.

In the pricked apples there were isolated spots discoloured and slightly depressed. Where there were four punctures together, in the form of a cross, the external discolouration took the same form, and sometimes extended to 1½ inches. There was a pinkish colour given to the tissue beneath, extending as deep as the punctures.

Corrosive Sublimate.—Various poisons were employed which were highly soluble and extremely penetrating, so that the effects were produced very rapidly, and corrosive sublimate or mercuric chloride may be taken as an illustration. A saturated solution in alcohol was employed, and a small portion of the surface was rubbed over with sterilized cotton-wool steeped in the solution. Mature apples of the Yates variety were used, and results were taken at the end of 48 hours. It produced a discolouration to a yellowish-brown tint, which extended a little beyond the area where it was applied, with a very distinct raised edge (Fig. 58). The discoloured portion was perfectly smooth and bright, and there were no pits or depressions of any kind. When a section

was made across the discoloured patches, there was a browning of the flesh beneath corresponding to the surface discolouration, and extending inwardly in a crescent form to about one-eighth of an inch.

After testing the effects of various chemical substances applied to the skin of the apple, I cannot emphasize it too strongly that all this production of external spots and smears has really nothing to do with Bitter Pit. This disease originates from within, and the action of an external agent on the skin is something totally different.

LOCAL POISONING.

The action of various poisons on the sensitive cells of the apple is now receiving the attention of various investigators, and it is an interesting bio-chemical problem to determine the nature and extent of the injury. Since arsenical poisons are now so extensively used in checking the Codlin moth, their effect upon the fruit has naturally been brought under notice, and, so far as these investigations dealt with the action of poisons on plant tissues, the results have been of great scientific value. But when spraying with such compounds was propounded as the cause of Bitter Pit in apples, then a new turn was given to the question, and evidence had to be adduced for or against the theory. Dr. Jean White (95) brought forward this theory in 1911, in a paper read before the Royal Society of Victoria, entitled "Bitter Pit in Apples," and it may be briefly stated, in her own words—"The results of my observations, and of the experiments performed, without one single exception so far, seem to indicate that the complaint popularly known as Bitter Pit is, strictly speaking, not a disease at all, but rather a symptom of slow local poisoning, and that in the cases actually examined so far, it appears to be due to the poisonous compounds sprayed on to the surface of the fruits for the eradication of pests, more especially insect pests." Bitter Pit was generally considered to be due to internal causes, and not to external agencies, but, apart from that, there were at least three fatal objections to the theory from the practical stand-point. First, I had plucked apples affected with Bitter Pit from trees which had never been sprayed with arsenical compounds. Second, I had received badly pitted apples from Western Australia, where the Codlin moth was practically unknown, and where, consequently, no spraying had been done. Third, there was reliable proof in official publications in South Australia that Bitter Pit existed there before spraying was thought of. Under these circumstances, I did not deem it necessary to pursue the subject further, but, by special request, I have carried out definite experiments to see if Bitter Pit was produced in the absence of spraying, and some of them are on the lines laid down by Dr. White herself in the paper referred to. "As I am anxious to have this theory proved or disproved as soon as possible, I should like to suggest that fruit-growers in the different States should test it in their own orchards. A good plan would be to leave one central tree unsprayed, and also those forming a kind of circle round it. In this manner the danger of spray material being deposited upon the surface of the fruit on the central tree would be minimized in an orchard which was otherwise sprayed."

EXPERIMENTAL EVIDENCE.

In an orchard at Deepdene, where the Cleopatra apple-trees were being cut down and re-grafted on account of Bitter Pit, I had twelve trees of this variety reserved, in order to test the effect of non-spraying. They were in a corner of the orchard, and care was taken, when the other trees were being sprayed, that none of the spray was carried in that direction. At the end of the season the result was that the twelve trees produced 23¼ lbs. of fruit, every apple being badly affected with Black Spot so as to be unmarketable, and twelve apples with Bitter Pit. (Fig. 122.)

In the Burnley Gardens a tree of the variety Annie Elizabeth, which is particularly subject to Bitter Pit, was specially reserved, together with others around it, in order to test the theory that spraying with arsenate of lead is the cause of it. This tree was sprayed in June, 1911, with red oil emulsion, but had no spraying of any kind afterwards. The Principal of the School of Horticulture kindly undertook to see that this tree and all the trees surrounding it were not sprayed with anything after the red oil emulsion, and precautions were taken to prevent any arsenical spray reaching the tree from a distance by the agency of the wind. Not only so, but as soon as the fruit had set, about 12th October, a number of clusters were enclosed in white calico bags, thus preventing the access of insects, and the possibility of the arsenical spray being carried to the fruit.

This particular tree is twelve to thirteen years old, on Northern Spy stock, and growing vigorously. The fruit was picked on 6th March, 1912, and that enclosed in the bags was kept distinct. There were 58 bags altogether, and in nine of these the fruit did not grow. (Fig. 111.)

It was interesting to observe that the fruit enclosed in the bags grew to the normal size, and occasionally there were faint red streaks on the fruit, but usually the colour had not developed. The fruit was carefully examined, with the following result:—In the bags there were 136 apples altogether, 75 of which were pitted, and 61 clean, 5 of the pitted apples being also "crinkled." On the tree there were 132 apples, 50 being pitted, 81 clean, and 1 with crinkle. Of the apples enclosed in the bags, 55 per cent. were pitted, and on the tree 39 per cent. Thus, a tree was treated in the manner suggested by the propounder of the theory, and in the exposed unsprayed fruits there was actually a less percentage of pitted apples than in the fruits protected by calico bags.

HISTORICAL EVIDENCE FROM AUSTRALIA.

As far back as 1886 Frazer S. Crawford, Inspector under the Fruit Act in South Australia, published a pamphlet, in which "Spotted Apples" were described in such a way as to leave no doubt as to the nature of the disease. In the same pamphlet he gave an analysis of the replies of the leading orchardists to questions concerning "Black Spot" or "Scab" of the apple, and there is not a single reference to spraying. Under the heading of "Remedies Tried," it is stated that one orchardist syringed the trees with kerosene soap. Since we have here a definite date when Bitter Pit was known in several varieties of apples in South Australia (not to mention the statement of the Honorable Thos. Playford, one of the oldest fruit-growers, that he first saw it in 1860), it can be shown that spraying, as an orchard practice, had not been then introduced. I am indebted for the following references to W. Catton Grasby, F.L.S.:—

In August, 1886, in a report of the meeting of the South Australian Gardeners' Society, held on 3rd July, Mr. F. S. Crawford mentioned that a local maker had constructed a spray nozzle upon the pattern of the cyclone. He considered that this would help in the spraying, but stated "the present difficulty was to secure a cheap and suitable pump for the work. They wanted a light affair, a pump in a bucket, which could be filled with the solution, and carried in the hand."

In the *Garden and Field* for December, 1886, Mr. Crawford referred to the cyclone nozzle, stating that he was not in any way the inventor, and incidentally establishing the date of the introduction of spray pumps into South Australia

In March, 1890, Mr. Crawford read a paper before the first Congress of the Agricultural Bureau of South Australia, in which he recommended spraying with Paris Green and other arsenical compounds. This is the first reference to the use of arsenic in South Australia.

Then, finally, the Angaston Experimental Committee was appointed to conduct a series of experiments, for the purpose of preventing or eradicating the fungus diseases of fruit-trees. Spraying operations commenced on 29th July, 1891, with a Dobbie's Triple Cyclone nozzle, and the materials used were Ammonio-Copper Carbonate, Eau Celeste, and Bordeaux mixture.

This was really the beginning of the general practice of spraying fruit-trees in South Australia, and Bitter Pit had existed there many years previously, for in his report of 1886, Mr. Crawford writes—" For several years I have received apples from various parts of the Colony covered with slightly depressed, roundish spots or pits, about one-eighth of an inch in diameter."

EVIDENCE FROM OTHER COUNTRIES.

In dealing with evidence from other countries, one must first be satisfied that the Australian Bitter Pit is identical with the disease so-called elsewhere, and in the references to be given there is definite proof that this is the case. In Germany, Sorauer has illustrated and described it in his " Atlas der Pflanzenkrankheiten " and in South Africa, Lounsbury has represented the disease in its natural colours. There is no doubt, therefore, that the same disease is referred to.

Dr. Paul Sorauer, the well-known author of a standard Text-book on Plant Diseases, writes me as follows, after a perusal of Dr. White's paper :—" I cannot adopt the view of Dr. White. With us the disease appears *without* the use of any spraying material, and, indeed, in many cases *isolated* in the fruit pulp, and then *without* being connected with the epidermis, so that the cause cannot come from the outside."

Dr. Galloway, Chief of the Bureau of Plant Industry, Washington, writes:—" Now, as to your question about Bitter Pit in relation to arsenate of lead. We have also found the Bitter Pit on trees not sprayed with arsenate of lead. Furthermore, the disease has been known for years in certain districts in the United States before the arsenate of lead was used in the orchards."

Lounsbury, Chief of Division of Entomology, Union Department of Agriculture, Pretoria, has written several pamphlets on the subject, and closely observed the disease in the orchard. In one letter to me, he writes :—" There are many parts of this country where it is still unnecessary to spray apple-trees with any arsenical compound whatever, and, indeed, with anything at all, and yet in many such localities Bitter Pit is very troublesome indeed. I have seen the disease bad in unsprayed gardens and orchards, both in the east and west of the Cape Province, and in the Transvaal." In another letter, he writes :—" That one may cause spotting of apples by chemical agencies is neither new nor surprising. The New York Geneva Station reported on a spot in some marketed apples years ago, which appeared to have been caused by some gas to which the fruit had been subjected. Similar injury was experimentally produced by sulphur fumes. I tried the experiment here, with like results. One might mistake such spots for Bitter Pit on slight acquaintance with the trouble. But our true Bitter Pit has its maximum development on the high plateau of South Africa, far from any source of atmospheric pollution, and utterly independent of any insecticide or fungicide. If arsenic in the soil were the cause, our soils must be terribly poisonous."

It will be seen that the evidence is all against Bitter Pit being caused by spraying, whether with arsenical or other compounds.

CHEMICAL EVIDENCE.

Apples and pears, both healthy and pitted, were submitted for analysis to Mr. P. R. Scott, Chemist for Agriculture, in order to determine whether arsenic were present or not, and in every instance the results were negative.

Table IV.—Specimens of Normal and Diseased Pears and Apples Examined for the Presence of Arsenic.

Skin only, Josephine Pears (Bitter Pit)	Negative
Diseased portion ,, ,, ...	,,
Skin only ,, (Normal)	,,
Pulp only ,, ,, ...	,,
Skin of Apple, Esopus Spitzenberg (Bitter Pit) ..	,,
Pulp of Apple ,, ,, ..	,,

Since it was known that unsprayed apples were affected with Bitter Pit, a committee was appointed, including Professor Ewart, to collect samples. The following varieties were obtained from orchards within a convenient distance of Melbourne, viz., Sturmer Pippin, Dumelow's Seedling, Northern Spy, and Rymer. They were carefully examined by the Biologist of the Agricultural Department, and acknowledged by the committee to be genuine cases of Bitter Pit.

The samples were examined for mineral poison, and the following report was forwarded by Mr. Scott:—Result of examination of unsprayed apples affected with Bitter Pit, for the detection of mineral poisons—" The samples were examined by the undermentioned methods:—The apples were first sliced and dried in a water bath, at 100° C. The dried material was then ground into powder and thoroughly mixed. A portion was then charred on a sand bath, at a low temperature, for about fifteen minutes, by means of strong sulphuric acid; then extracted with hot water, and tested for arsenic in Marsh's apparatus, afterwards treated with hydrochloric acid, and likewise tested in Marsh's apparatus.

" Another portion of the dried material was incinerated at a low heat, and the ash dissolved in hydrochloric acid, and a current of sulphuretted hydrogen was passed through the solution. I did not obtain any mirror by means of Marsh's test or coloration of liquid precipitate by the sulphuretted hydrogen.

" The examination, therefore, revealed no evidence of the presence of mineral poisons in the fruit."

The presence of Bitter Pit in unsprayed apples has now been conclusively proved, and it has been produced in trees where no spray of any kind was used. Chemical analysis also failed to reveal the presence of mineral poisons, so that the theory that spraying with poisonous compounds is the cause of Bitter Pit is no longer tenable.

Since writing the above, I have received a copy of the " Proceedings of the Royal Society of Victoria," issued March, 1912, in which Professor Ewart (32) contributes a paper " On Bitter Pit and the Sensitivity of Apples to Poisons." As he shows in this paper " that it is not necessary to withdraw or modify any part of Dr. White's paper, except in so far as her tentative theory, that the source of poisoning might be from poisonous sprays, only holds good partly, for Bitter Pit may also occur in orchards which have never been sprayed with poisonous compounds," there is no necessity to repeat the account of the rebutting experiments carried out as suggested by Dr. White herself. The occurrence of Bitter Pit in unsprayed orchards has now been acknowledged, and the only explanation given is that " the poison must be absorbed from the soil." He further acknowledges that to find out what poisons are absorbed from the soil or subsoil is " a chemical problem of some difficulty," so that the chemist will require to make a special examination of the soils of our orchards for this purpose. Professor Ewart has carried out a vast amount of research work in connexion with " The Sensitivity of Apples to Poisons," both in uninjured fruit and " prepared " fruit, *i.e.*, when fragments of the cuticle were removed without injuring the cells beneath the epidermis. (Part I.) The action of poisons including poisonous sprays on the tree itself, as well as on the fruit, is a subject well worthy of investigation, especially under Australian conditions, and the professor deserves great credit for having initiated it. But

it is only when the results of these researches are used to elucidate "The Problem of Bitter Pit" (Part II.) that comment becomes necessary here. In answering the question, Can surface poisoning produce deep-seated Bitter Pit tissue? he freely acknowledges that "in all the experiments on adult apples the effects were always produced, first at the point where the poison was applied, and thence radiated inwards, but in normal Bitter Pit, the dead tissue may sometimes be deep-seated without any apparent connexion with the exterior." Where the Bitter Pit tissue is entirely deep-seated, and there is no perceptible connexion with the surface, he attributes it to "the absorption of minute traces of poisons through the roots, or less probably, of volatile substances from the air."

The concluding paragraph of the paper summarizes the salient points as to the relation between Bitter Pit and local poisoning. "On three points, however, it may, I think be stated with confidence, that we are on a solid bed-rock of established fact, namely, that Bitter Pit is, strictly speaking, not a disease at all, but is a symptom of local poisoning, produced in the sensitive pulp cells of the apples, that more than one poison may produce it, and that such poisons may be derived from more than one source."

When it is affirmed by Professor Ewart that deep-seated Bitter Pit is "the result of the absorption of minute traces of poisons through the roots," there is no notice taken of the action of these poisons on the roots themselves. But, in order to understand this process of absorption by the roots, it will be necessary to glance at the soil solution, and how it gains an entrance inside the plant.

The supply of water must come from the soil, and from this soil solution the tree draws, through its roots, all the materials required in growth, except the carbon dioxide absorbed through the leaves or other green portions of the plant. The mineral constituents dissolved in this soil solution will vary in amount, and in their degree of concentration. This concentration will affect the growth and development of the lower organisms which are concerned in the fertility of the soil, and if the solution is too concentrated, it interferes with growth.

It is now believed that there is an optimum degree of concentration at which the plant will grow best. Cultivation prevents excessive concentration of the soil solution, and the effects in this direction of green manuring and fertilizers have yet to be studied.

But the soil solution, containing the nutritive materials required by the plant, must be absorbed, and the concentration within the cells become more or less equalized with that without, before the plant can be properly nourished. How this is accomplished will now be shown.

Although the roots are surrounded by the soil solution, the root hairs do not suck in or absorb the mineral constituents dissolved in it like a sponge. They must pass from the outside to the inside of the cells, and there is a membrane or cell-wall lined with living protoplasm, which guards the entrance. This plasmatic membrane, as it is called, only allows certain substances to pass through, by a process of diffusion. When this diffusion takes place through membranes or partitions, it is distinguished as *osmosis*.

This diffusion of liquids, that is to say, of substances dissolved in water, was first seriously studied by Graham, beginning in 1849, and it is to him we owe the clear distinction between the colloid or jelly-like and the crystalline states of matter and the introduction of colloid membranes as a means of separating the two kinds of substance. The use of these colloid membranes is of special interest, because the lining membranes of vegetable and animal cells are of this nature.

In a communication by him to the Royal Society of London, on "Liquid Diffusion applied to Analysis," he thus explains the process:—"A sheet of very thin and well-sized letter-paper, of French manufacture, having no porosity, was first thoroughly wetted, and then laid upon the surface of water contained in a small basin of less diameter than the width of the paper, and the latter depressed in the centre, so as to form a tray or cavity capable of holding a liquid. The liquid placed upon the paper was a mixed solution of cane sugar and gum arabic, containing 5 per cent. of each substance. The pure water below and the mixed solution above were, therefore

separated only by the thickness of the wet sized paper. After 24 hours the upper liquid appeared to have increased sensibly in volume, through the agency of osmose. The water below was found now to contain three-fourths of the whole sugar, in a condition so pure as to crystallize when the liquid was evaporated on a water bath."

Here we see that the sized paper does not act as a filter to allow the substances contained in the water to pass indiscriminately through, but diffusion takes place through the water contained in interspaces in the colloid substance. In this case the sugar only passed through, and "the membrane is always permeable for a certain substance, when this substance is soluble in the material of the membrane." That this is so was afterwards clearly demonstrated by Nernst. It is known that ether is soluble in water as well as in benzene, but that benzene is soluble in ether only, and insoluble in water. When a quantity of benzene and a quantity of ether are separated from each other by a layer of water, a continuous stream of ether passes through the water, but there is no streaming of benzene in the opposite direction. Nernst carried out the experiment by substituting an animal membrane saturated with water for the layer of liquid water. A glass funnel was connected with a glass tube, and the benzene was poured into the funnel, which was closed with the saturated membrane. The funnel was then dipped into a vessel containing ether, and, after a certain time, the liquid rising in the glass tube showed the streaming in of the ether. The ether, soluble in water, passes through the membrane, while benzene does not, and an osmotic pressure or resistance is produced on the side of the benzene. The membrane does not act like a sieve, and Czapek, in his "Chemical Phenomena in Life," says, "All signs show rather that solution affinities play the most important part in diosmosis."

It has also been shown recently, by Professor Adrian Brown, that cereal grains, such as barley, are provided with a lining membrane, close to the outer skin of the seed, which acts as a differential partition, so that the food materials stored up in the seeds should not pass outwards during germination, nor harmful materials pass in to check or stop growth.

Although, as Professor Armstrong points out, in an article in *Science Progress* for April, 1912, "We have consequently to consider the diffusion not of a single substance, but of an unknown number of substances, and the problem becomes one of great complexity," yet it is clear that the assumption of Professor Ewart, that poisonous substances are absorbed by the roots, and injure the fruit, is not proved. Such substances, if admitted, would certainly have an injurious influence on the roots themselves, as well as on the whole tree. Yet it is the young and vigorous trees which pit badly, and the trees are otherwise quite healthy which are subject to it, and even the roots of the Prince Bismarck tree (Fig. 133), which had been sprayed with arsenate of lead, so far showed no ill effects.

It seems to me that if the theory of local poisoning is to be proved or disproved, investigation should begin at the roots, and not at the fruits. The remarkable sensitivity of the pulp cells of the apple to poisons has been shown. What about the sensitivity of the delicate cells of the root?

Professor Ewart seems to have confined his attention exclusively to the pulp cells, without taking into account the fact of prime importance in connexion with Bitter Pit, that these cells are permeated by a rich supply of vessels which convey the food materials to them, and on which their very existence depends, and I venture to think that if these vessels, as well as the wonderful vascular network immediately beneath the skin, where the Bitter Pit originates (see Figs. 83, 86, 90), had been recognised, he would have arrived at a very different conclusion.

I cannot better conclude this section than by quoting the remarks of Professor P. J. O'Gara (68), in his article on the "Absorption of Arsenic by Apples from Spray," where he shows how totally different the peculiar spotting of apples caused by arsenate of lead is from Bitter Pit. "A careful examination of the spotted apples shows that only the epidermal and sub-epidermal cells are injured, so that the injury may be said to be only skin deep."

"The spot in no way resembles 'Baldwin Spot,' which is always to be found affecting the tissues beneath the epidermis, and which may go to a considerable depth in the flesh of the fruit. The Baldwin Spot is a physiological trouble, and is due to the abstraction of water from the cells. In the Baldwin Spot the epidermis usually remains intact, although the cells beneath it may have become disorganized."

X.—DISEASES ASSOCIATED WITH BITTER PIT.

In calling attention to the diseases found associated with Bitter Pit, my object is not only to guard against their being confused with that disease, but mainly to show that the conditions favouring the one are not antagonistic to the other. The four principal diseases found by myself were—(1) Black Spot, or "Scab," caused by a fungus known in its parasitic stage as *Fusicladium dendriticum* (Wallr.), Fckl.; (2) Bitter Rot, known in the summer stage as *Gloeosporium fructigenum* Berk.; (3) Glassiness, or Water-core; and (4) Mouldy core, due to a common mould.

BLACK SPOT, OR SCAB.

In the early stages of this disease, when the spots are minute and scattered over the fruit, it is sometimes mistaken for Bitter Pit, more especially when associated with it. It is not uncommon to find the two diseases together, favoured by the same climatic conditions, although the Black Spot may be on one portion of the fruit, and the Bitter Pit on another. In Australia the orchardist is generally familiar with the appearance presented by Black Spot, and recognises it as such, but in South Africa Lounsbury (50) states that the two are commonly confused.

In Black Spot not only is there an evident fungus causing it, the velvety growth on the blackish spot consisting of spores, but the blemish is confined to the skin, whereas in Bitter Pit there is no fungus growth, and beneath the skin the pulp is found in spots to be brown, dry, and tough. (Fig. 62.)

BITTER ROT.

I have found this disease occasionally associated with Bitter Pit. (Figs. 63, 64.) As the name denotes, the taste of the affected tissue is bitter, but just as in Bitter Pit, it varies from a pronounced bitter taste to one which is hardly distinguishable. The infection by the fungus usually starts at one or a few places, but it sometimes occurs at numerous spots scattered over the surface. It is then superficially not unlike Bitter Pit, since the spots may become depressed, owing to the shrinkage of the affected pulp beneath, and at first there may be no external growths of the fungus. But, with the characteristic development of the fungus, as shown in Fig. 65, there is no longer the slightest resemblance. The spore-pustules are arranged in concentric rings, from which the spores ooze out in pinkish masses, and soon dry up.

GLASSINESS, OR WATER-CORE OF THE APPLE.

This is also a disease due to internal causes, but its symptoms are quite distinct from those of Bitter Pit, and the two have only been found associated together on rare occasions. Its appearance is familiar to the orchardist, and it is most frequent in wet years, especially if the rain occurs about the time the fruit begins to ripen. Large varieties, with hard, firm flesh, are most subject to it, and early varieties rather than late. In Victoria, among the worst are Mela Carlo, Stone Pippin, and Stewart's Seedling. In the former variety particularly, it is difficult in some seasons to get a single apple off a tree entirely free from it. In the Burnley Gardens the disease

was first observed on 21st December, in White Astrachans, fully ripe. The tree was about 25 years old, and the apple is very soft-fleshed, so that the disease is not always confined to hard-fleshed varieties.

The appearance of an affected apple is very characteristic. Externally the portion affected has a waxy or glassy appearance, and this never extends over the entire apple. It usually embraces the upper half or three-quarters, and the stem end is generally normal. (Figs. 66, 67.) The transparent watery glassy appearance may occur over smaller or larger patches. When a cross section of the apple is made, the glassiness is seen to extend even to the core (Fig. 68.), and it is so firm and hard that it does not yield to the pressure of the finger. The cells composing it are all fully distended and turgid, so that they resist pressure. The glassy portion has a sweetish insipid taste, and is deficient in the natural flavour of the sound portion. When analysed, it is found to contain an excess of water, and a corresponding deficiency in acids and ash-constituents.

The cause of the watery appearance is due to the intercellular spaces being filled with water instead of air, as is usually the case. This may easily be shown by taking a microscopic section just at the junction of the healthy and the glassy tissue. If water is added, the air in the ordinary tissue is replaced by water, and becomes transparent. The sound pulp is white, owing to the air in the intercellular spaces.

Glassy fruits are not only deficient in flavour, but they do not keep as well as the sound ones off the same tree. On account of the excess of water, and the small acid and sugar content, the internal diseased portions soon decay, and even the skin, which is remarkably thick over the glassy portion, soon decays, and turns brown.

It is generally observed that young trees are more liable to produce glassy fruit than when they are older, although here, again, it is so dependent on a combination of conditions that no absolute statement can be made.

The three varieties most subject to it in Germany are given by Sorauer (85), as follows:— Transparent de Zurich, White Astrachan, and Gloria Mundi. The fruit of the two former is small or medium, while in the latter it is very large, one weighing 28 ounces having been grown in South Australia.

It has been found in the following varieties in Victoria:—

Cornish Gilliflower.
Early Almond.
Irish Peach.
London Pippin.
Lord Suffield.
Lord Wolseley.
Mela Carlo (absolutely the worst).
Prince of the Pippins.
Red Must—Cider Apple.
Roundway Magnum Bonum.
Stone Pippin.
White Astrachan.
Wine.
Winter Majetin.
Yarra Bank.

It is interesting to notice that Sorauer (85) attributes this glassy condition to some local disturbance of the conducting tissue, while Pole Evans (31) considers it to be "undoubted evidence of watery exudation under pressure." He says—"The cell sap fills the cells to overflowing, but, instead of bursting them, quietly diffuses through their membranes or walls, and then accumulates in the intercellular spaces." This certainly accounts for the intercellular spaces being filled with a watery fluid, but it does not explain why, in "glassiness" of the apple, the water filling the cells to overflowing does not burst their walls, but quietly diffuses through them, while in "Bitter Pit" of the apple the same condition of affairs causes the bursting of the cells. The bursting of the cells in the interior of the apple, due to too great internal pressure, is the most plausible theory yet put forward to account for Bitter Pit, but it must be evident that there is a contradiction here between the bursting of the cells in the one instance, and their turgid resistance to it in the other. The contradictions will be reconciled when it is recognised that it is to the *conducting tissue* we must look for the primary cause, and not to the cells themselves surrounding or adjoining it.

"Glassiness" has been found associated not only with Bitter Pit, but also with "Crinkle," in some cases very common, and in others very rare. It has been suggested that "glassiness" may become Bitter Pit by the heat turning it brownish beneath the skin, but, although they may be associated under similar conditions, they are quite distinct in their manifestations.

MOULDY CORE OF APPLE.

This disease is very common in the Cleopatra or New York Pippin, and in this instance is associated with the Bitter Pit. (Fig. 9.) On cutting it across, the core is found to be filled with a white mould (Fig. 10), and it soon spreads, causing the entire apple to become worthless and rotten. The mould gains an entrance from the blossom end, which is open, leaving a passage to the core. This opening to the core from the eye is very important in connexion with the keeping qualities of the apple, and its relation to Bitter Pit was also observed. Since the Cleopatra variety has large, open channels leading to the core cavity, and is very liable to Pit as well, some orchardists have come to the conclusion that the open eye has something to do with the Pit. But, when a number of varieties are carefully examined, it is found that the open or closed channel to the core cavity is not a constant quality, and may vary in the same variety. Thus, Annie Elizabeth, which is also very liable to Pit, had a closed passage when grown in one district, and an open channel, with "mouldy core," when grown in another. Further, Five Crown or London Pippin is also subject to this disease, and has an open channel, but it is only slightly liable to Pit. So that there is no proved connexion between an open passage from eye to core and liability to Pit, but it is being observed, as a correlated character.

XI.—VARIETIES OF APPLE AFFECTED WITH BITTER PIT.

Any one who has carefully inspected an orchard at the proper season, where a number of varieties of apple trees are grown, must have been struck by the fact that not only are certain varieties much more liable to the disease than others, but that some of them are absolutely or practically free from it. And, when he extends his observations to other districts, and even to other States, he finds that this immunity or liability to the disease is not constant, but that a variety regarded as free in one district may be liable in another, and one slightly affected under one set of conditions may be badly affected under another. It is also well known that one season may be favorable to it, and another unfavorable, so that the season, the soil, and the locality may all have an influence on the result.

Confining our attention for the present to the Commonwealth of Australia, and compiling lists, as given by responsible authorities in each State, the principal varieties affected are as follows:—

VICTORIA.

Very Bad to Bad.	*Medium.*	*Slight to Very Slight.*	
Annie Elizabeth.	Delicious.	Ben Davis.	Reinette de Canada.
Buncombe.	Duchess of Oldenburg.	Dumelow's Seedling.	Rome Beauty.
Cleopatra.	Esopus Spitzenberg.	Five Crown or London Pippin.	Rymer.
Cox's Orange Pippin.	Hoover.	Gravenstein.	Scarlet Nonpareil.
Lord Wolseley.	Nickajack.	Jonathan.	Statesman.
Magg's Seedling.	Perfection (Shepherd's).	Munroe's Favourite.	Stone Pippin.
Northern Spy.	Prince Alfred.	Pomme de Neige.	Winter Majetin.
Prince Bismarck.	Rokewood.		
Ribston Pippin.	Sturmer Pippin.		
Shockley.			

NEW SOUTH WALES.

Bad.	*Slight.*	*Free.*
Cleopatra.	Adam's Pearmain.	Dunn's Seedling or Munroe's Favourite.
Esopus Spitzenberg.	Cox's Orange Pippin.	Five Crown or London Pippin.
Hoover.	Jonathan.	Rokewood.
Northern Spy.	Lord Wolseley.	Rome Beauty.
Ribston Pippin.	Maiden's Blush.	Stone Pippin.
	Nickajack.	Yates.
	Rhode Island Greening.	
	Rymer.	
	Shepherd's Perfection.	
	Winter Majetin.	

QUEENSLAND.

Bad.	*Slight, or sometimes Quite Free.*	
Cleopatra.	Baldwin.	Irish Peach.
Emperor Alexander.	Cellini.	Jonathan.
Lord Suffield.	Devonshire Quarrenden.	Lord Nelson.
Northern Spy.	Dumelow's Seedling.	Prince Bismarck.
	Esopus Spitzenberg.	Reinette de Canada.
	Five Crown or London Pippin.	Ribston Pippin.
	Gloria Mundi.	Rome Beauty.
	Gravenstein.	Shepherd's Perfection.
	Hoover.	Twenty Ounce.

SOUTH AUSTRALIA.

Badly Affected.	*Moderately Affected.*	*Seldom Affected.*	*Never Affected.*
Baldwin.	Cornish Aromatic.	Adam's Pearmain.	Five Crown or London Pippin.
Cleopatra.	Cox's Orange Pippin.	Buncombe.	Rokewood.
Esopus Spitzenberg.	Dumelow's Seedling.	Dougherty.	Rome Beauty.
Garibaldi.	Jonathan.	Dunn's Seedling.	Stone Pippin.
Hoover.	Lady Henniker.	Morgan's Seedling.	
Northern Spy.	Maiden's Blush.	Newtown Pippin.	
Ribston Pippin.	Prince Bismarck.	Nickajack.	
Scarlet Nonpareil.	Shepherd's Perfection.	Reinette de Canada.	
Shockley.	Sturmer Pippin.	Rymer.	
	Winter Majetin.	Strawberry Pippin.	

WESTERN AUSTRALIA.

Bad.	*Slight.*	*Free.*
Cleopatra.	Dunn's Seedling or Munroe's Favourite.	Yates.
	Esopus Spitzenberg.	
	Five Crown or London Pippin.	
	Jonathan.	
	Rome Beauty.	
	Shockley.	
	Stone Pippin.	
	Sturmer.	

TASMANIA.

Bad.

Adam's Pearmain.
Annie Elizabeth.
Cleopatra.
French Crab.
Marie Louise.
Northern Spy.
Reinette de Canada.
Ribston Pippin.
Scarlet Pearmain.
Sturmer Pippin.
Wellington.

Slight.

Cox's Orange Pippin.
Gloria Mundi.
Hoover.
Lady Henniker.
Prince Alfred.
Prince Bismarck.
Rhode Island Greening.
Shepherd's Perfection.

AUSTRALIAN SEEDLING APPLES IN THEIR RELATION TO BITTER PIT.

With the assistance of the Principal, I have made a list of those growing in the Horticultural Gardens, Burnley (Appendix IV.), and they are being closely watched with regard to their susceptibility to Bitter Pit, so that at the close of the investigation some idea may be formed as to those which are worthy of being more extensively cultivated for commercial purposes on account of their appearance and quality and comparative freedom from Pit.

From that list it will be observed that during the past season some of them were badly pitted, and seedlings, such as Prince Bismarck and Borrowdale, were about as bad as any in the Gardens.

This is not quite in keeping with the experience of Pole Evans (31), in South Africa, who found that "One of the most significant facts in connexion with this investigation is that only those varieties of apples which escape Bitter Pit and which show immunity towards it are those which may be described as Colonial apples." Now, while there is no doubt that climate is an important factor and that there is a decided advantage in growing trees from seed, suited to the conditions prevailing in the country of their origin, yet there are other factors to be taken into account. Heredity has to be reckoned with, and the source of their origin will have an effect upon their susceptibility to the disease. Thus, a Northern Spy seedling raised in the Burnley Gardens is very badly pitted year after year, and it is being discarded on that account. There are 100 listed altogether, and there is always the possibility of some seedling apples being discovered in which the tendency to pitting has been reduced to a minimum. The treatment which the tree receives is important, as the following remarks by the raiser of the "Western Belle" seedling will show—"As regards its liability to suffer from Bitter Pit, I may say that while I winter-pruned the tree and the fruit was extremely large, a large proportion of it was badly pitted. Since I have left off winter-pruning it, and the bearing branches have become more or less pendent, the tree yields clean fruit."

VARIETIES AFFECTED AT BURNLEY HORTICULTURAL GARDENS SEASON 1911-12.

As regards varieties liable to Bitter Pit in Victoria, I have selected for special observation the splendid collection of apple trees in the Burnley Horticultural Gardens, where Bitter Pit is to be found more or less every year. This will form a basis for successive years and various correlated characters will be given to see how far they influence the development of Pit. Thus, it will be noted whether the pitted varieties are firm or soft fleshed, early or late maturing, &c., and the stock will be recorded where known. (Appendix V.)

Special attention was also given to the period when Bitter Pit was first observed in the different varieties, and, since they vary so much in their relative stages of growth and as the date would not convey a correct idea of their age, I have designated the time according to the stage of ripening. What constitutes ripeness has not been definitely settled in a practical way, but we have to distinguish between the ripening which takes place upon the tree and to which it contributes, and the maturing which occurs after picking, and is generally spoken of as after-ripening. In ripening then the fruit is brought to its full size and development through the activity of the parent-tree, and in after-ripening the fruit is dependent on its own resources.

This list of varieties with their relative susceptibility to Bitter Pit will be recorded each year on similar lines, together with any new varieties which may develop it. The result will be that at the end of the investigation the liable varieties will be more or less definitely determined. With such a severe test for susceptibility to this disease, a number of promising Australian seedlings and varieties not generally known may be found worthy of being brought into general cultivation.

XII.—THE GENERAL STRUCTURE OF THE APPLE AND PEAR.

The apple and pear are what are known as "pip" fruits, and, since they possess a special structure which distinguishes them from ordinary fruits, they have received the technical name of *pome.* Wherein this peculiarity consists and which has an important bearing on the susceptibility of such fruits to Bitter Pit and kindred diseases, will now be considered.

The apple is attached to the end of the parent-branch by a longer or shorter stalk, through which the necessary nourishment is conveyed to it; and if a section lengthwise and crosswise is made of the fruit, as in Figs. 69 and 71, the essential parts will be shown. The apple, unlike other normal fruits, does not merely consist of seeds enclosed in a case, but surrounding that case there is the "flesh" of the apple. If we glance at the flower before the fruit is developed, there is seen at the centre of it a five-chambered ovary, and each chamber encloses normally two ovules. After fertilization, the ovules become the "pips" or seeds, so that there are now five carpels or seed-vessels, constituting the true fruit, with thick fleshy walls, but the inner face of each, bounding the seed-cavity, is smooth, firm, and cartilaginous in texture.

The five carpels enclosing the seeds constitute what is known as the "core" of the apple, and this represents the true fruit or the mature and fertilized portion. Surrounding the core there is the flesh covered by the skin, and this is superadded in order to enhance the attractiveness of the fruit and increase the chances of the distribution of the seeds.

While the core is undoubtedly represented by the five carpels, there is a conflict of opinion as to the origin of the flesh, but it is generally considered to be the enlarged and succulent receptacle or top of the flower-stalk investing the core. A pomaceous fruit, therefore, consists of an edible portion and a seed-bearing portion, and, while the seed-bearing portion is the true fruit, the edible portion is simply added to render the whole attractive, and when eaten by animals, to insure the deposition of the seeds under suitable conditions for germination.

The object of the grower is to produce "flesh," and not "seed," which is a drain upon the vitality of the tree, and there are some "seedless" apples now under cultivation.

The pear in its essential structure agrees with the apple, but differs in detail (Figs. 78, 79). The configuration is different, for there is an elongated tapering fleshy portion towards the stalk end, so that the core is towards the crown. It also differs from the apple in containing groups of what are known as "stone-cells" scattered through the flesh, constituting the "grit" of the pear. These will be more fully considered in connexion with the skeleton.

The question has been raised as to the relative size of core in large and small apples, and to answer it I have taken six of each of the Prince Bismarck variety off the same tree. The measurements were as follows :—

TABLE V.—RELATIVE SIZE OF CORE AND FLESH IN LARGE AND SMALL APPLES.

	Large Apples.		Small Apples.	
—	Diameter of Apple. Inches.	Diameter of Central Core. Inches.	Diameter of Apple. Inches.	Diameter of Central Core. Inches.
1	3·00	1·37	1·94	1·12
2	3·50	1·50	2·00	1·12
3	3·25	1·37	2·06	1·12
4	3·25	1·50	2·20	1·12
5	3·25	1·50	1·80	1·00
6	3·00	1·37	2·00	1·00
Total for 6 Apples ..	19·25	8·61	12·00	6·48
Average for 6 Apples ..	3·21	1·43	2·00	1·08

It has been stated that the core in a small apple is just as large as in a big one, but the above measurements do not bear this out. The core in the large apple is larger than the core in the small apple, but the proportion to the diameter in the large apple is *less* than that in the small apple. In other words, there is more core relatively to the flesh in a small apple than a large one of the same variety.

It is generally considered that the core has reached its full development before the flesh at the periphery of the apple has ceased growing.

XIII.—THE FIBRO-VASCULAR SYSTEM AND ITS FUNCTIONS.

In any modern description of the disease of Bitter Pit, it is generally stated that it is developed in connexion with the vessels, but, if the vascular system is carefully laid bare in the apple and pear, and the wonderful ramifications exposed to view, as in Figs. 83 and 88, it would be difficult to find any large area of the flesh not provided with an abundant supply of vessels.

We are able now to give a clear and connected view of the wonderful system of vessels ramifying through every portion of the fruit, and accompanying the conducting system there is always a strengthening system or skeleton, both being included under the one term, "Fibro-vascular."

If an apple is cut across about the middle, ten green spots are observed arranged in a circle about midway between the centre and skin (Fig. 71). These are the primary fibro-vascular bundles or strands of the apple, and they are evidently harder and firmer than the surrounding tissue, for if the cut surface is allowed to dry these ten points stand out distinctly. From their position, they are evidently developed in connexion with the five carpels, for there is one strand opposite each of the seed-cavities, and another in an intermediate position, making ten in all.

Strong corroborative evidence is afforded that the bundles are developed in connexion with the carpels by the fact that when the abnormal number of six carpels occur, there are twelve bundles instead of ten (Fig. 72), and when there are four carpels there are only eight strands (Fig. 73).

But these vascular bundles in the apple are continued from the stalk, and, when a transverse section is made of the stalk, the ten bundles are seen arranged in the form of a cylinder (Fig. 96). Sometimes, adjoining bundles have coalesced, but they are sufficiently distinct to be recognised (Fig. 95). The number of vascular bundles in the fruit are determined by those in the stalk, for, when an apple was found with only four carpels, there were only eight bundles in the stalk.

In a longitudinal median section of the apple, each of these ten vascular bundles is seen to give rise to branches, which in turn branch again and so on, mostly towards the outside, although there are several branches on the inside (Fig. 94). From each of these ten strands, just as they are leaving the stalk, branches are given off to the outer and inner face of the seed-cavity, so that the seeds are well supplied. The main strands, however, are associated with the "flesh," and the diverging branches towards the outside do not divide much until they approach the skin, where they form a perfect network (Figs. 86, 90). This vascular net envelopes the flesh about one-quarter of an inch or less from the surface, and this wonderful and hitherto unsuspected structure not only unites the entire system of vessels, but gives rise to the innumerable plume-like branches which reach even to the skin (Fig. 91). These arise from the boundaries of each mesh of the net, and they divide and subdivide in such a luxuriant manner that the ultimate branchlets interlace and intertwine so as to form a seemingly continuous layer of conducting tissue beneath the skin. They penetrate the cells immediately beneath the epidermis (Fig. 85), which are particularly rich in chlorophyll, and take an active part in the nutrition of the growing and swelling fruit. In the longitudinal section, the main strands are seen to come together again just at the "eye," where they pass out into the calyx, corolla, and stamens, so that the entire flower, including the carpels, is fully supplied with vascular bundles.

The green colour of the bundles, seen in a cross section of the apple, is due to chlorophyll. This is made evident when a longitudinal section of the bundle is made. The chloroplasts or chlorophyll-granules are seen not only in the cells intermixed with the vessels, but also in cells outside of them. They are ellipsoid in shape, and vary in size, but generally average 3–4½ microns in length.

VASCULAR BUNDLES AS A WHOLE.

In order to get a connected view of the vascular system as a whole, it is necessary to remove the soft parts, so that the strands of conducting tissue may be isolated. In the case of the apple, the bundles were separated out by means of a dilute solution of potassium hydrate. After macerating in this for a week, the soft pulpy material was readily detached, leaving the strands intact. It was laid out in water, and, by means of brush and needle, all the soft parts were removed, leaving only the ten strands, with their ramifications, as photographed. (Fig. 88.)

We are all familiar with the Egyptian Loofah, or Towel Gourd, used like a sponge for the bath, and which is just the fibro-vascular bundles of the fruit of *Luffa ægyptiaca.* It is probably prepared by retting or steeping in water, to get rid of the soft parts. The "skeleton" of the apple leaf, formed by exposure to the weather, is also a familiar object (Fig. 130). In the case of the pear, it was found that after immersion for five days in ordinary tap water, the skin could be easily peeled off, and the flesh removed, so that the vascular system, forming a complete outline of the fruit, stood out distinctly, as in Fig. 83. The quince is a little tougher, and required longer immersion in water, but the vascular network is similar, with the innumerable projecting, plume-like branchlets.

FUNCTIONS OF THE BUNDLES.

The functions of the bundles are twofold. There is a vascular portion, to convey the nutritive fluid to each part where wanted, and a fibrous portion, to strengthen the delicate cells and prevent collapse. It is necessary to understand how the growing apple is nourished, in order

to appreciate the extensive distribution of the vascular system. It is not simply the developing seeds, with the case containing them, which require to be nourished, as in ordinary fruits, but also the much larger mass of tissue outside of that, constituting the flesh. So much growth has to be made in a comparatively short time that the apple tree has to store up the necessary material during the previous season, for the early spring growth. The short branches, known as fruit-spurs, bear the fruit-buds, which are plump, and well nourished, in order to give rise to the blossom. The material stored up in the branches is passed on to the flowers when they are fertilized. It is easy to tell, within a few days, when fertilization has occurred, for the flower-stalk stiffens and begins to swell. This stiffening and thickening are due to the rush of food-materials, and after the fall of the petals the stored-up food is practically exhausted. Then the young apple is partly nourished by the parent-plant, with its fresh green leaves, and partly by its own exertions. The water, containing mineral matter in solution, enters from the soil, passes along the roots, and up the stem, until it reaches the fruit-spurs. Here it enters through the stalk of the fruit, and is distributed along the various channels, until it bathes the tissues wherever the fine network reaches.

The amount of water contained in a ripe and sound apple is 84 per cent., on an average, so that a proper water supply is all-important for the formation of the fruit. The fruit increases in size, not so much from the multiplication as from the enlargement of the cells, and it can readily be understood how nicely the balance must be adjusted, in order to regulate the supply. The water-stream will be directed along the main channels towards the apex of the fruit, and if the cells are overgorged, then the vascular network may not be able to keep pace with the expanding cells, and if there is a dearth of water, a concentration of the contents of the cells may follow.

The leaves of the tree, under the influence of sunlight, are now busy manufacturing starch, some of which will be transported in the soluble form of sugar to nourish the growing fruit, which is, however, able to a certain extent to provide for its own needs in this respect. The chlorophyll-containing cells of the hypodermal layer are also producing starch, under the influence of sunlight, so that, from these two sources—the green leaves and the green layer of the fruit—abundance of starch is formed in a normal season. This has to be rapidly transported, when the fruit is swelling, from the place of manufacture to the tissues, where wanted. The insoluble starch is rendered soluble by means of a ferment; and the use of the innumerable connected and branching veinlets in the hypodermal tissue will now be evident. In the fruit-growing season there is a great drain upon the plant's resources, and the manufactured starch must be quickly removed, in order to make room for fresh supplies, for, as Pfeffer remarks, "The solution of starch is hastened by the continual removal of the sugar produced."

But the green apple is not merely a consumer, using the material supplied for building up its tissues; it requires to store up material towards the period of ripening, and starch grains are invariably found in the cells of unripe fruit. According to Browne (102), "The percentage of starch in apples varies entirely with the age of the fruit; in green apples it may amount to 5 per cent. or more, while in the completely-ripened fruit it is altogether wanting."

The vascular bundles, as a whole, can now be understood. In a transverse section of the stalk, just as it enters the fruit, there are ten vascular bundles, although sometimes two adjoining may become confluent. (Fig. 95.) These, on entering the fruit, spread out to form ten main trunks, with numerous branches (Fig. 89), and conveniently situated about midway between the skin and the centre. The earliest branching and the most direct course is towards the carpels and the seeds, then the flesh is supplied by numerous diverging branches, which unite to form a network of vessels, and finally terminate beneath the skin, in a perfect maze of the most delicate forked veinlets. So richly is the apple supplied with a connected system of vascular bundles that it would be difficult to find an area of any size without them.

The reason for this extensive distribution of vessels is evident, since the developing fruit must be richly supplied with food-materials, to maintain the rapid growth. The water, containing mineral matter in solution, the so-called "crude sap," is conveyed by the wood-portion of each bundle, with its vessels and tracheids (Fig. 98). The solution of organic food-material, the so-called "elaborated sap," passes along the bast-portion, with its sieve-tubes and associated cells; and, by means of numerous cross connexions between the two kinds of tissues, there is a blending of the "crude" and "elaborated" saps, which results in the formation of proteid substance; and this, in contact with the living protoplasm, becomes converted into the living substance itself.

The vascular system must not be conceived of as a vast network of tubes conveying food-material to a definite terminus, but as being tapped on the way by living tissues wherever growth is going on, or storage is required. The movement of the food-materials takes place in whatever direction supplies are wanted, and even in the same cell or vessel there may be a flow in opposite directions at the same time.

VASCULAR BUNDLES IN RELATION TO THE SEEDS.

That the vascular bundles are developed primarily in connexion with the "core" comprising the carpels, and gradually spread out into the fleshy receptacle, is evident from various considerations. When a coloured fluid is injected into the stalk of the apple, it first spreads out into the cavity containing the seeds, and thus the "pips" or seeds are the first to be supplied with the nutritive fluid. But very striking evidence is also afforded that the development of the seed influences the growth of the fleshy receptacle, for when only some of the ovules are fertilized and produce seeds, it is found that the apple is rather one-sided. The seedless portion does not grow as rapidly as the other, because the vessels conducting the food-materials are not so luxuriantly developed. Thus, the position of the bundles in the wall of the core, their direct communication with the seeds, and their sparing development when no seeds are formed, all point to an essential relationship between the two. The branches from the main bundle supplying the seed spread out over each carpel in the form of a delicate network (Fig. 94), and thus a regular and equable distribution of food-material to the seeds is provided for.

VASCULAR BUNDLES IN RELATION TO EACH OTHER.

The primary vascular bundles in the apple, just as in other portions of the tree, do not remain isolated and disconnected, but, by the anastomoses which take place, particularly towards the periphery, there is continuity throughout. The entire system is comparable, in this respect, to the anastomosing veins and arteries of the human body, only we must be on our guard against speaking of "circulatory" tissues, or of the "circulation" of water or foods, as if there were a central organ to and from which the nutritive fluids were directed. On the other hand, we must remember that, even in the apple, there is a connected and not a scattered system of vascular bundles (as Strasburger erroneously stated), which branch out from the stalk, and distribute food-materials to every part, passing along each of the five chambers to supply nourishment to the seed, and spreading outwardly among the cells of the flesh.

To show this intimate relationship, it is not necessary to use the microscope, but simply to macerate the apple, and remove the pulp, leaving behind the skeleton and the vessels, as in Figs. 83 and 88. Brooks (9), by means of frozen apples, was able to remove the soft flesh in water, and show the large vascular strands giving off branches towards the periphery and over the carpels. But that wonderful network of vessels immediately beneath the skin, which also occurs in stone-fruits, such as the plum, was unsuspected, and the means whereby the regular and equable distribution of the food-material is carried out, in the region where the greatest and most rapid growth occurs, was not then known.

THE SKELETON.

Just as in animal structures the skeleton is closely associated with the principal blood-vessels, in order to strengthen and support them, so in the plant-body the vessels are bound up with what represents a skeleton, and the whole is spoken of as a Fibro-vascular bundle. The apple starts as a small fruit, and with little flesh (Fig. 74), but this gradually grows to a good size, when it requires a framework to support it. Such a mass of pulpy tissue would collapse by its own weight unless there were some means of strengthening it. The distended cell-walls of the tissue itself would tend to stiffen it, just as in a firm leaf, when the cells are all turgid; but strengthening rods are required as well. There are ten of these curved supports, like the ribs of an umbrella, normally equidistant from each other, diverging from the stalk at the base, and uniting again at the top, just beneath the eye. These strengthen the whole structure, like so many curved ribs, and the various branches form lesser supports. It will be observed that this system of strengthening is not merely mechanical; it is also a living mechanism, which has to grow and expand according to the strain it has to bear. The young fruit of a Cleopatra apple, when the petals have just fallen, and fertilization has occurred, is about one-eighth of an inch in diameter, and forms a direct continuation of the stalk, being completely enveloped by a dense mass of silky hairs, which are readily scraped off. When placed in a dilute solution of caustic potash it becomes of a dark, ruddy-brown colour, and is thereby sharply marked off from the green stalk. The bulk of the young fruit consists of the "core," as seen in section (Fig. 74), which has the ten primary vascular bundles surrounding its margin, and there is a thin layer of parenchymatous tissue between them and the skin. After macerating for four or five days in the caustic potash, the skin can easily be removed, and just immediately beneath it there is the fine network of vessels, just as in the mature apple, only of exceeding fineness, like a spider's web (Fig. 93). So this wonderful network of vessels exists from the earliest stages of the fruit, and has to go on growing and expanding until maturity is reached, always accommodating itself to and endeavouring to keep pace with the enlarging bulk of the flesh.

The skin is likewise a form of skeleton, giving firmness and consistency to the entire fruit, but its structure and functions will be considered in the next section.

XIV.—THE SKIN OF THE APPLE AND PEAR.

The skin is not only a form of skeleton, but it has an important influence on the amount of moisture given off from the fruit, and its main function is to regulate transpiration. It is noticeable how quickly an apple or pear will dry up or decay when it is pared. As showing the efficiency of the skin for the purpose, I had a pear of the Broompark variety and a Jonathan apple peeled and unpeeled, and kept in a dry atmosphere for 48 hours. The loss in weight was carefully tested by Mr. P. R. Scott, Chemist for Agriculture, with the following results:—

TABLE VI.—LOSS OF WATER IN WHOLE AND PEELED APPLES AND PEARS AFTER 48 HOURS.

Weight of whole pear before desiccation, 261.569 gr.; after, 260.0355 gr.
Weight of peeled pear before desiccation, 176.677 gr.; after, 172.5190 gr.
Weight of whole apple before desiccation, 133.4895 gr.; after, 132.737 gr.
Weight of peeled apple before desiccation, 112.065 gr.; after, 108.8538 gr.
No. 1 whole pear, 0.586 per cent. loss after 48 hours.
No. 2 peeled pear, 2.35 per cent. loss after 48 hours.
No. 3 whole apple, 0.563 per cent. loss after 48 hours.
No. 4 peeled apple, 2.87 per cent. loss after 48 hours.

Thus the peeled pear had lost over four times as much as that of the whole pear, and the pared apple had lost over five times that of the unpared.

The skin consists of several layers of cells, an outer single colourless layer known as the *epidermis*, and several inner layers of coloured cells containing chlorophyll, and known as *hypodermis*. The outer walls of the epidermal cells in the mature fruit are strongly thickened, and there is a continuous layer of a transparent substance of varying thickness overlying all, which is known as the cuticle (Figs. 106 and 107). In some varieties there is a surface covering of wax, which is finely granular and dust-like, easily rubbed off, the so-called "bloom." Inside the skin there are the cells of the "flesh," or pulp cells, which at first are somewhat similar to the cells of the hypodermal layer, and then become large and bladder-like.

This is the structure found in the mature fruit, but if the young fruit is examined, the cells of the epidermis are seen to be much smaller, the outer thickening is not yet strongly developed, and there is a dense layer of hairs which is subsequently dropped before ripening (except in the case of the quince). There are also openings in the skin to admit air, and to allow the escape of gases, generally of a different nature to those in the fully-formed fruit.

As the young fruit grows, there will necessarily be an enlargement of the surface, and the epidermis must keep pace with it. How this is accomplished will now be shown. There is a tangential growth of the epidermal cells, so that there is sufficient stretching to keep up the continuity of the skin. At the same time the shape of the cells undergoes a change, and they become plate-like, while they soon divide into two or more daughter cells, forming the so-called "window-cells" (Fig. 105). But, if growth is very rapid, and the daughter-cells cannot stretch fast enough, each daughter-cell may in turn divide like the parent, and there may be not only primary and secondary, but tertiary and even quaternary subdivision. In this way arises the mosaic seen on a surface view, and, as division and subdivision go on, the cell-walls become relatively thinner and thinner, so that the amount of subdivision taking place can be determined thereby. It can readily be understood that when after a dry spell, for instance, there comes a rush of sap, so that the growth of the flesh is so rapid that the skin cannot keep up with it, then something must give way, and small rents are produced, as well as a disruption of the stomata, to be replaced by minute openings, which, in their function and mode of origin, correspond to the lenticels.

The cuticle varies in thickness in different varieties, and generally it is thinner in early than in late varieties; but no general rule can be laid down. The width of the cuticle is sometimes given as characteristic of certain varieties, but, since fruits taken from the same tree on the shady and sunny side respectively show greater differences than that between different sorts, it is not a reliable test. The bloom or wax on the outside will prevent the adhesion of water, and thus tend to render the fruit less liable to the attacks of fungi.

STOMATA AND LENTICELS.

If the skin of a young apple is examined microscopically, it is found to be invariably studded with numerous breathing pores or stomata (Fig. 101), and even in full-grown apples they sometimes persist. They are more numerous in smooth-skinned than in rough-skinned varieties, and their distribution is not always quite symmetrical in the ripe fruit. In apples they are more crowded towards the crown end, and in pears towards the stalk end, the greater relative growth of the lower portion of the apple and the swollen upper portion of the pear having caused a greater amount of stretching, and consequently the stomata are further apart.

When, later in the season, the thickened outer membrane of the epidermis is subjected to considerable surface tension on account of the rapid growth, rupture occurs, and it is generally in the direction of the stomata. In this way the stomata are replaced by star-shaped points studding the surface, characteristic of several varieties. They are often recognised by the naked eye as white

points studding the skin, as in Yates, where the cavity beneath is filled with air as well as the numerous surrounding intercellular cavities. These points serve the purpose of lenticels, although without their typical structure. In some varieties, however, lenticels of the normal character occur.

CORKY OR ROUGH SKIN.

When the epidermis is unable to keep up with the rapidly enlarging surface of the apple, it may be replaced by a corky layer in patches or all over the surface, and this is broken up into larger or smaller scales, which are often shed on the further growth of the fruit. Sometimes it is only here and there that the epidermis is ruptured and replaced by cork, so that large patches of the epidermis remain intact among the scattered corky patches. This rusty network is very prominent in many pears, such as Beurré Clairgeau, and various apples, such as the Reinettes.

The corky layer originates in the epidermis itself, and only arises when the epidermis has become incapable of tangential growth, in consequence of excessive thickening and cuticularization of the outer wall. It is therefore generally the case that early delicate-skinned sorts remain smooth, while late ripening apples and pears, whose epidermis is strongly thickened, become rough-skinned. In fruits unsymmetrically developed it is always the larger side which shows a tendency to form cork, because there the epidermis is exposed to such great tension that it is ruptured.

It might appear, from this account of the formation of "russetiness," that it only occurred when the conditions of growth were such that the epidermis became torn and ruptured when the fruit was swelling, and these torn places were enclosed by a corky layer. But other factors must enter into it, since it is a natural characteristic of many varieties.

In some cases, at least, the amount of russetting varies according to the conditions under which the apples are grown. There is a favorite shipping apple known as Dunn's Seedling or Munroe's Favourite, which is so commonly russetty at the stalk end that in a description of it by James Lang, of Harcourt, in the *Victorian Journal of Agriculture* for July, 1904, this is given as a characteristic of it. "Stalk short, and set in a deep cavity, lined with russet." It might be explained that the deeply-sunken stalk end showed excessively rapid growth, which caused the epidermis to be ruptured and cork formed. But I find on inquiry that in Victoria and South Australia it occasionally occurs perfectly smooth, more particularly when it is grown in localities which rarely receive rain after the fruit is formed. North of the Dividing Range in Victoria, the cracking at the stem end is only met with in wet seasons, and at other times the skin is smooth like wax, even at the stalk end. In West Australia sometimes as much as 30 per cent. of the crop are free from this defect. At Stanthorpe, Queensland, nearly 3,000 feet above sea-level, this variety is grown in small quantities all over the district, without any scurfiness at stalk end.

SUB-EPIDERMIS, OR HYPODERMIS.

The epidermis, or outer layer of the skin, is of prime importance, not only because it protects the cells beneath from excessive evaporation, but because it places them in communication with the oxygen of the air for respiration, and carbon dioxide for carbon-assimilation. But the inner layers of cells immediately beneath the epidermis are also important, not only from contributing to the firmness and thickness of the skin or rind, but from their influence on the appearance and keeping quality of the fruit, owing to their green colouring matter and tannin (Fig. 106). Although the hypodermis passes gradually into the fleshy part of the apple, yet it is distinctly different. The cells composing it are smaller, tangentially elongated, or elongated parallel to the surface, with tolerably thick walls, and richly provided with chlorophyll, which gives the green colour to the unripe fruit. Towards the time of ripening, the green colour gradually changes to a yellow or a red, and the process is similar to that which occurs in the production of the autumn tints in leaves. The red

colouring matter dissolved in the cell-sap originates, according to Pick (116), from tannin under the influence of sunlight; but since the red colour is sometimes all over the fruit, on the shady as well as the sunny side, it cannot be altogether dependent on direct sunlight.

The presence of tannin in this layer is made evident when sections are being cut with a razor. In the freshly plucked or unripe apples, there is often a blue coloration produced, due to the action of the iron on the tannin. And even the taste of the skin in many varieties indicates the large amount of tannin present, for in pears particularly the skin has to be removed before they can be eaten with pleasure. The relation of tannin and the production of starch in this region, to the development of Bitter Pit, will be dealt with later.

XV.—RESPIRATION OF THE APPLE.

Plants are living things, and therefore they breathe just as animals, by taking in oxygen and giving out carbon-dioxide gas, commonly called carbonic acid. Respiration in the animal body is a recognised sign of life, and the cessation of the process is regarded as a sign of death. In the plant body there is not the same striking evidence, so that the breathing of plants or parts of plants is not so generally known. But it is just as necessary for the plant as for the animal, since the products of respiration are the same in both, viz., carbon dioxide gas and water, and it is the energy derived from the oxidation of the various compounds during this process, that enables the plant to maintain its vital activity.

Living plants or parts of plants, however, can still continue to respire or give off carbon dioxide gas, even when the supply of free oxygen is cut off. This is known as *intramolecular respiration*, and, under such conditions, apples and pears, for instance, can still live for months. While the apple is attached to its parent shoot, it may still be supplied with nourishment to make good the loss due to respiration, but when it is picked from the tree, then it has to draw upon the materials stored up within itself. Each living cell of the apple respires, and, when the fruit is placed in storage, there is a steady loss in weight, although it remains sound and firm. This is clearly shown by Morse (113), who placed apples in cold storage in November, and weighed them at intervals of two months :—

	Loss.
January	·33 per cent.
March	2·34 ,,
May	3·60 ,,
July	4·71 ,,

The reduction in weight is naturally thought to be due simply to the loss of water, but analysis shows that the percentages of water and dry matter are practically constant, so that if solid matter did not disappear as in the ordinary process of respiration, there would be a decreased proportion of water and an increased proportion of dry matter.

Morse has calculated the rate at which the apple changes its composition, at a summer temperature and in cold storage, by an ingenious experiment, whereby the carbonic acid gas breathed out of the apples was collected and measured. "It will be seen on comparing the average rates of exhalation of carbonic acid at the different temperatures, that, in passing from melting ice (32° F.), to cellar temperatures (45° to 50° F.), the rate nearly triples, and in passing from the medium temperature to summer temperature the rate doubles."

"Since the breathing out of carbonic acid is an indication of the rate of chemical change within the fruit, it follows that changes of composition must take place from four to six times as fast at summer temperatures, as in cold storage, and from two to three times as fast in cool cellars as in cold storage."

Respiration does not cease, therefore, in cold storage ; it is simply less active.

But it has been proved repeatedly at the Doncaster Cool Stores that, when sound apples are placed in cool storage immediately and kept there at a constant temperature of 30–32° Fahr., their vital activities are suspended, and there is no development of Bitter Pit.

XVI.—CHEMISTRY OF THE APPLE—SOUND AND PITTED.

The apple has already been considered from the botanical point of view, and it is important to distinguish between the "core," which is the true fruit, and the fleshy succulent portion outside of that, which is just an excessive development of the expanded top of the flower-stalk. It is the aim of the orchardist to produce a luscious and edible apple, and to keep the core from monopolizing too much of the nourishment, so much so that attempts have been made to grow a so-called "seedless" apple, and thus get as large a proportion of flesh as possible. It is the vegetative portion of the fruit which requires to be stimulated, and not directly the sexual organs, and, therefore, those measures should be resorted to which tend to the production of foliage leaves, for while the fruit remains green it transpires and respires and behaves exactly like a leaf. As ripening takes place the colour changes, and chemical processes are set up of quite a different kind. It is necessary, therefore, to understand in a general way the chemical changes which take place, both in the unripe and ripe fruit.

CHEMICAL COMPOSITION OF THE APPLE.

The analysis of the apple shows that it largely consists of water, the percentage usually ranging from 82 to 86. Also of sugars, which are the most valuable of all the constituents, and next to water in abundance. Then of acids and crude fibre, together with the residue which remains when all the combustible material has been disposed of, viz., the ash. In a perfectly ripe apple there is no starch, since it has been converted into sugar. The chemical composition of the flesh of the average ripe apple may be represented as follows, according to Browne (102) :—

Table VII.—Composition of Flesh of Average Ripe Apple.

	Percentage.
Water	84·00
Ash	0·30
Invert Sugar (Dextrose and Levulose) ..	8·00
Cane Sugar or Sucrose	4·00
Crude Fibre	1·80
Pectin Matter	0·40
Malic Acid, free and combined	0·80
Oil or Fat	0·30
Protein	0·10
Undetermined (Tannic Acid, &c.)	0·30
Total	100·00

The ash or mineral matter of the apple, although small in quantity, is of great importance, since the removal of large crops of apples every year means that the soil will in time become impoverished unless the annual loss is made good.

The percentage composition of the mixed ashes of a number of varieties is as follows :—

TABLE VIII.—PERCENTAGE COMPOSITION OF ASH OF APPLE.

	Percentage.
Potash	55·94
Soda	0·31
Lime	4·43
Magnesia	3·78
Oxide of Iron	0·95
Oxide of Aluminium	0·80
Chlorine	0·39
Silica	0·40
Sulphuric Acid	2·66
Phosphoric Acid	8·64
Carbonic Acid	21·60
	99·90

Most of the constituents of the ash are present in abundance in the soil, but phosphoric acid and potash are two ingredients in danger of becoming exhausted.

The pectin bodies are carbohydrates, allied to the gums, and they serve a useful purpose in the preparation of apple jelly, for the property of setting or gelatinizing is entirely due to them.

Tannins are contained in solution in the cell-sap, and are only present in small amount. When apples are freshly cut, it is supposed that the oxidation of the tannin by means of a ferment causes the flesh to turn brown.

Malic acid gives the sour or acid taste to apples. It exists in the free or combined state, in the latter case combining with certain bases, principally potash, to form salts.

It is sometimes asked by the orchardist whether an apple badly affected with Bitter Pit has been chemically analyzed, and the analysis compared with that of a sound apple of the same variety grown in the same soil, as if that might solve the difficulty of Bitter Pit. An analysis has been made of both apples and pears, pitted and sound, and each was taken from the same tree. Josephine pears and Stone Pippin apples were used, and the following is the result of the analysis by Mr. P. R. Scott :—

TABLE IX.—ANALYSIS OF SOUND AND PITTED APPLES AND PEARS.

	Josephine Pears.		Stone Pippin Apples.	
	Clean.	Pitted.	Clean.	Pitted.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Moisture	84·55	83·87	83·43	81·62
Organic Matter	15·07	15·70	16·15	17·90
Ash	0·38	0·43	0·42	0·48
Total Acidity as Malic Acid	0·167	0·101	1·035	0·871
Alkalinity of Ash as c.cs. of 1/10 N. Acid on 1 gram	0·38	0·46	0·413	0·454
Specific Gravity of Juice	1·053	1·0535	..	1·061
Baumé	7·9	7·85	..	8·7
Temperature of Reading	20·25° C.	20·5° C.	..	17° C.

The moisture is slightly less in the pitted apple, the organic matter a little higher, and the ash slightly in excess. The malic acid is also reduced, but there is no striking difference in chemical composition.

Next, a clean and a pitted apple of the Lord Wolseley variety were taken from the same tree at the Burnley Horticultural Gardens for analysis. Apples of the same variety and from the same tree were also obtained from Bacchus Marsh, and the clean and pitted portions only submitted to analysis.

Table X.—Analysis of Clean and Pitted Lord Wolseley Apples (from Burnley Horticultural Gardens).

—	Clean.	Pitted.
Weight of Apple	274·62 grms.	277·75 grms.
Moisture, Water Oven at 112° C.	87·34 per cent.	85·41 per cent.
Moisture, Vacuum at 70° C.	86·84 ,,	85·04 ,,
Total Acidity (as Malic Acid) per 100 c.c. of Juice ..	·77 ,,	·73 ,,
Total Acidity (as Malic Acid), per cent. of whole Apple ..	·647 ,,	·600 ,,
Tannin (Zinc Sulphate method) per 100 c.c. of Juice ..	·074 ,,	·106 ,,
Tannin (Zinc Sulphate method) per cent. of whole Apple	·062 ,,	·087 ,,

Table XI.—Analysis of Clean and Pitted Portions only of Lord Wolseley Apples (from Bacchus Marsh).

—	Percentage of Whole Amount Taken.	
	Clean Only.	Pitted Parts Only.
Extract at 100° C.	11·84	12·46
Total Ash	0·271	0·352
Alkalinity of Ash in c.c. of $\frac{N}{10}$ Acid per 100 grms. of Apple	20·05	35·08
Total Acid (as Malic)	0·71	0·54
Volatile Acid (as Acetic) (Steam Distillation)	0·048	0·048
Cane Sugar	2·91	2·39
Total Reducing Bodies (before Inversion)	7·25	8·07

If a comparison is made between the constituents of the clean and pitted portions of the same variety of apple, at the same stage of ripeness, it is found that in the pitted portion there is less moisture, the total ash is slightly larger, the malic acid is also slightly less, while the amount of cane sugar and reducing bodies combined is practically the same. Tannin was determined in the entire apple, and found to be slightly in excess in the pitted.

The juice of the apple, in clean and pitted, was also determined, with the following result :—

274·62 grams of clean apple gave 195 c.c. of juice.
277·75 grams of pitted apple gave 195 c.c. of juice.

Since a larger quantity of the pitted apple than the clean was required to yield the same amount of juice, there is, therefore, slightly less juice in the pitted than in the clean apple.

GROWTH.

In the life history of an apple there are three distinct periods—growth, ripening, and decay. In the growth, complex chemical changes occur which are not too well known, but some of them have been definitely determined.

The organic matter of the apple is primarily formed in the green leaves of the tree and in the green skin of the fruit itself. There the chlorophyll grains, in the presence of sunlight, manufacture starch, which is converted into sugar by the action of a ferment, and is conveyed to the growing portions of the fruit. Some of this sugar is reconverted into starch by starch-forming bodies, not to be stored up as reserve material, however, but to be used in building up new tissue, at least the cell-walls.

If apples are examined at different periods of growth, it is found that, with the increase in sugar, there is a decrease in starch, and that the free malic acid gradually becomes less. When an apple is full grown, it still contains starch and malic acid, but towards the period of ripening there is a decrease in both. It is generally considered that the sweetness of an apple depends on diminished acidity and an increased percentage of sugar, but sour apples frequently contain more sugar than fruit of a sweeter kind, so that the taste is dependent on the absence of the acid. While the apple is growing, there is very little variation in the percentage of water.

RIPENING.

In the ripening of the fruit, certain changes take place which can be followed by ordinary observation. The skin usually changes its colour, the relatively hard flesh becomes soft, the sour taste turns to sweetness, and a delicate aroma is generally developed, characteristic of the variety. When the chemist follows the changes, he finds that the starch in the unripe fruit has become converted into sugar, and the agreeable flavours are apparently due to ethers which have been produced by the union of the vegetable acids with alcohol formed by the partial breaking down of the sugar. The formation of alcohol does not require the presence of yeast, as in ordinary fermentation, for if an apple is placed in a jar containing no oxygen the ordinary oxidation of sugar into carbonic acid and water does not take place, but it is broken down into the less oxidized form of alcohol.

The pectin bodies present in the pulp of apples to the extent of 0.2 to 0.6 per cent. show a marked diminution in the process of ripening, but Pfeffer (115) doubts whether this decrease is due to their conversion into sugar, &c.

RIPENING OF APPLES IN ORDINARY AND COLD STORAGE.

This has been specially studied by Bigelow (100), and he gives analyses of several varieties picked at different dates and kept in ordinary and cold storage respectively. From the results obtained, it appears that "the changes in composition (the content of starch, sugar, and acids) in cold storage do not greatly differ from those which occur in common storage, the chief difference being in the rapidity with which the changes take place."

When samples were removed from cold storage and kept in ordinary storage, it was found that "the apples ripened much more rapidly than those kept in cold storage, and that, before the samples were destroyed by rot, they had closely approximated the composition attained by the apples in cold storage some months later." The ripening which takes place upon the tree and that which occurs after picking, or during the period of after-ripening, is not quite identical in its results. It is the general opinion of fruit-growers that the proper time to pick apples is when they have attained their maximum size and weight, even although hard, since it is found that they keep better and have a finer flavour than when allowed to ripen on the tree.

What constitutes ripeness is not definitely settled in a practical way, for some growers are guided by the brown colouration of the "pips." But the test of complete ripeness lies in the absence of starch, and tincture of iodine will show its presence in the pulp by a blue colouration.

In ripening, the earliest disappearance of starch is at the core, and this is correlated with the fact that the core is fully developed before the flesh has ceased growing. "As the apple ripens, starch begins to disappear near the centre of the fruit, and later at the periphery. The last traces are to be found in the cells adjacent to the fibro-vascular bundles." (113.)

XVII. ANALYSIS OF REPLIES TO QUESTIONS BY FRUIT-GROWERS.

A circular containing questions regarding Bitter Pit (Appendix III.) was sent to the principal growers in the different States (with the exception of Queensland), and an analysis of the replies is here given. There were 125 replies to this circular received from Victoria, representing the principal fruit-growing districts, 24 from New South Wales, 21 from South Australia, 43 from Western Australia, and 34 from Tasmania, making a total of 247 replies received. The opinions are rendered the more valuable from being the outcome of the personal experience of growers in widely-separated States.

The experience of the orchardists varied from a few years up to fifty, and quite a number had twenty to thirty years' experience. In the great majority of cases only apples were affected, as in only ten orchards in Victoria was the disease reported on in pears, in five in South Australia, in one each in Western Australia and Tasmania, while in New South Wales there was no record of it in pears. Dr. Cobb (19), however, in 1903, figured it in pears under the name of Stigmonose, and referred to it as a "disease common in all the Australian States."

VARIETIES OF APPLES AFFECTED AND IMMUNE.

As regards liable and immune varieties, there is the greatest diversity of opinion, depending very often on the particular district, and the conditions under which they are grown. It would be very misleading to regard as immune those varieties which have not shown Pit in certain districts, and no useful purpose would be served by giving the liable varieties recorded in each of the different States. The lists given by the horticultural experts for each State of the liable and comparatively free varieties will, therefore, be taken as giving a fair average. Some orchardists record all their varieties as being absolutely free except Cleopatra, while others reply —"I cannot state with certainty that any variety is or is not absolutely free." In Victoria, for instance, fourteen growers have mentioned Pomme de Neige as being absolutely free, and a New South Wales orchardist states "Pomme de Neige, or 'Snowy," as we call it, is the only variety I have with Bitter Pit." In Victoria, too, it has been found pitted, although not very common. (Fig. 48.)

A South Australian grower replies—"None are absolutely free, but the following varieties are practically resistant:—Dunn's Seedling, or Munroe's Favourite, Rome Beauty, London Pippin, and Rokewood." In Western Australia Yates is given as a certainty, and some add Munroe's Favourite and Rokewood, and in Tasmania Munroe's Favourite is also given as free. Both Rokewood and Munroe's Favourite have been found with Bitter Pit in Victoria (Fig. 6), and while Cleopatra may be regarded as one of the most susceptible, Yates is the only variety that has stood the test of immunity for a number of years.

WHEN DISEASE FIRST APPEARED.

As a rule a disease is only specially noticed when it has become very destructive, and in its early beginnings attracts but little attention. Besides, in the matter of dates, the memory is often apt to play us false, and this must be remembered in connexion with the recollections of very old growers. Among Victorian orchardists, Mr. Lang, of Harcourt, remembers it "about 40 years ago," Mr. Fankhauser, of East Burwood, states that "it was very pronounced in Cleopatra in 1876," Mr. Lawrey, of Kinglake Nurseries, remembers it in apples in 1878; and Mr. Wahner, of Muckleford, about 1876.

In New South Wales 1898 is the first year recorded.

In South Australia, Mr. Hurn, of Angaston, says—"Fully 35 years in apples, but we have never known it in pears"; and Trescowthick Bros., Angaston, remark—"It appeared in the Cleopatra apples 43 years ago." Mr. Vickers, of Forest Range, dates its appearance in apples from 1880, and in pears from 1910. The disease has been definitely described by Frazer S. Crawford as occurring in South Australia in 1886, and the Honorable T. Playford first saw it in 1860.

In Western Australia the earliest date given is 1891, by Mr. Sandow, Cottesloe Beach.

In Tasmania one states that "it has always been here," and Mr. White, Beaconsfield, remarks —"I can remember it in the New York (Cleopatra) over 40 years."

AGE OF TREES WHEN FRUIT FOUND AFFECTED.

A number state that the fruit is affected at all ages, from the time the trees begin to bear, but worst on young trees making vigorous growth, and bearing light crops. One has expressed this view very neatly—"The younger the tree, and the larger the fruit, the worse the Pit seems to be." It is generally considered that old trees are not so liable, but still it occurs. An experienced orchardist, Mr. Lang, of Harcourt, states—"I have seen affected fruit on young trees first year bearing, and in all stages up to 40-year old trees." In New South Wales it also occurs at all ages, but mostly on young trees. In South Australia it is the same, but only one orchardist states—"At all ages, more so in old trees." In Western Australia the general view is expressed "From commencement of fruiting to twenty years of age and upwards," and in Tasmania at "all ages, but fruit from young and vigorous trees worst."

STAGE OF GROWTH OF FRUIT WHEN DISEASE FIRST OBSERVED.

This will depend so much on the variety that general statements do not count for much, for in some varieties it generally developes in store. Most have observed it when the fruit is nearly full grown and nearly ripe, but very few in the comparatively young stage. There are the various gradations of half, two-thirds, and three-quarters grown, and some have only observed it in store. Only two have observed it in a very early stage of the fruit, one "when about the size of a large walnut," and another "in bad cases before Christmas, when the fruit is the size of a walnut." One observes, however, "In the Williams' Favourite apple in my garden the Pit was noticeable soon after the fruit set."

In New South Wales it is generally observed when the fruit is nearly full grown, and sometimes when half developed. "Some when half grown, some after being stored."

In South Australia when three-fourths to full size.

In Western Australia when about three parts to nearly full grown, although occasionally when about half grown. "By close inspection it can be discovered when the apples are about three parts matured."

IS DISEASE WORSE IN A LIGHT CROP OR A HEAVY ONE?

Growers are generally agreed that a light crop suffers most when the fruit is large.

In Victoria only seven growers observed no difference, and four considered a heavy crop the worst. "I have trees with heavy crops affected, and trees with light crop, generally the largest fruit." "The heavier the crop, the less severe is the Pit."

In New South Wales two growers saw no difference. "Worse when bearing a light crop. Northern Spy was quite free when bearing a heavy crop last season, 1910–11."

In South Australia, with the exception of two, who considered there was no difference, and one, who found it worse in heavy crops, the growers were unanimous as to the effect of light crops. "It is invariably much worse on trees bearing a light crop, and large fruit."

In Western Australia three considered that the heavy crop was the worst affected. "I have frequently observed that in the 'off-year' fruit was badly affected, and in the year of 'heavy crop' the disease was hardly noticeable."

In Tasmania four growers observed no difference, and two considered the heavy crops worst affected. "It attacks both heavy and light crops." "We never have it with a heavy crop."

PREVALENCE OF PIT IN DIFFERENT CLASSES OF SOIL.

The general impression among growers is that the nature of the soil has not much to do with the prevalence of Bitter Pit. At least, in Victoria nearly twice as many orchardists consider that it has no influence upon it as those who do. It is generally stated, however, by the minority that it is worse in wet and heavy soil, and less prevalent in poor sandy soil. "In rich soil that causes rank growth you get more Pit." "It is worse where the clay is near the surface." "I have noticed Bitter Pit worse on rich land badly drained than in poor soil well drained."

In New South Wales the majority did not notice any difference in different soils.

In South Australia it is generally considered that the soil has an influence. "The richer the soil, the worse the Pit." "It is most prevalent in rich black loams or retentive clay subsoils. It is almost if not quite absent on well-drained sandy or limestone soils."

In Western Australia, curiously enough, opinions are equally divided as to the influence of the soil on the prevalence of Pit. "No difference, one tree may be clean, and the next very bad." "Rich moist soil, producing good growth, are worse for Bitter Pit than light dry soils."

In Tasmania the opinions are also about equally balanced. "The Pit comes in any class of soil." "Ground that is naturally drained, and inclined to get 'hot' during summer, always shows more Pit."

MANURING, AND ITS EFFECT ON BITTER PIT.

In Victoria a number consider that manuring has no effect upon the disease, but a large number regard it as conducive to the disease, as it stimulates growth. Several are of the opinion that stable manure is decidedly favorable to it. "Stable manure certainly increases the disease." "We had one tree, Shockley, close to a manure heap, affected worse than any other." Mr. Lang replies—"Have used muriate of potash, sulphate of potash, and superphosphate, combined with green manuring, for a number of years (twenty years), but the manuring does not seem to have had any effect upon the disease." "When trees are not manured growth is not so rank, consequently Pit is not so prevalent." Those who have tried lime generally found it to have no effect on Bitter Pit, although an occasional grower found it beneficial. "I have tried gypsum, ½ ton per acre, and green manuring, with good results."

In New South Wales there has not been much manuring of orchards, judging by the replies sent in, but both farmyard and fowl manure rendered the disease worse.

In South Australia very few are able to state the effect of manuring from experience. "Ploughed in green stuff, no effect; stable manure, an ill effect; bone-dust, lime, and washing-soda, a beneficial effect." "Manures have an effect upon the disease, particularly organic and nitrogenous, which stimulate wood growth. Phosphates are the safest fertilizers."

In Western Australia very little manuring is done. "Have found very little Pit in Shockleys, even when a light crop, when field peas have been ploughed in for green manure." "Excess of manure, especially green manure, has a bad effect." Lime has been applied, with and without beneficial results.

In Tasmania it is generally stated that heavy manuring increases disease, but one replies—"We found, by using stable manure and artificial, and leaving more lateral growths, Pit disappeared." Green manuring is also well spoken of. "I ploughed in 40 acres of peas last spring, and the crop was certainly better as regards Pit." Lime has been used in a number of cases, but generally without any appreciable effect.

EFFECT OF DRAINAGE UPON DISEASE.

The effect of drainage is regarded by some as of no consequence, and by others as the principal cause. "I am convinced that deficient drainage is one of the prime factors in causing the disease." "Where land is thoroughly drained the disease is not so prevalent." "I have found Bitter Pit very bad in the Cleopatra in a dry situation."

As regards drainage in New South Wales, it is considered to be beneficial. "The trees that had Bitter Pit were on low land, while the same kind of apple on higher land was sound."

In South Australia opinions are divided, but it is generally considered that "the better drained, the less Pit."

In Western Australia the general opinion is that want of drainage aggravates the disease. "Cleopatra worse where damp."

In Tasmania there is an impression that good drainage lessens the disease, but, as one puts it—"It is found that disease is present in well-drained and badly-drained orchards."

INFLUENCE OF MODE OF CULTIVATION ON DISEASE.

There is a very general impression that cultivation increases the Pit, and some even state that "the better the cultivation the worse the Pit." In Victoria the preponderance of opinion is that cultivation has no influence on the disease, but a large number consider that cultivation has a tendency to increase the trouble. Only one states that "well cultivated land will lessen the prevalence," but the others make such remarks as "found those in grass without cultivation the freest," and "I have noticed trees not cultivated do not produce so much affected fruit as trees that are cultivated."

In New South Wales it is mostly considered that cultivation has no influence on the disease, and the only one who thought differently remarked, "Anything that makes the tree vigorous increases the Bitter Pit."

In South Australia opinion is about equally divided as to whether cultivation influences the disease or not. "Disease worse in well cultivated soil." "As a rule good cultivation tends to increase Pit, but under certain conditions it may have just the opposite effect."

In Western Australia there is a general opinion that too much cultivation encourages it, but one considers that good cultivation "keeps disease in check," and another that "early cultivation appears to lessen the disease."

In Tasmania it is generally considered to influence the disease, although it must be taken in connexion with other factors. "Its influence depends upon other circumstances—pruning, manuring, class of soil, &c." "I have seen pit with high cultivation, and in neglected orchards also."

INFLUENCE OF SYSTEM OF PRUNING ON DISEASE.

The system of pruning is generally believed to influence the disease, and severe or hard pruning is considered to favour it.

In Victoria more than double the number of orchardists are of opinion that pruning has to do with the disease than that it has no influence upon it. "Heavy pruning on Williams' Favorite will make the trees rotten with Pit. Prune lightly, leaving laterals to run sap off, and the disease is lessened 75 per cent." "When the laterals are left long or unpruned altogether (if not too long) a large percentage of clean fruit will result." "To leave most of the long laterals with fruit spurs attached is beneficial; it exhausts the rapid flow of sap, and the fruit matures gradually." "Have found it bad in both severe and light pruning."

In New South Wales it is generally considered that the system of pruning affects the disease, and invariably it is stated that severe pruning encourages it. "Heavier the pruning the worse the disease." "It would be a mistake to heavily prune any tree subject to Pit which was growing vigorously."

In South Australia the great majority are convinced that severe pruning accelerates the disease. "Severe pruning is the cause of the whole trouble in our experience." "The harder trees are pruned the more subject they are to Pit; but a great deal depends on the method of pruning and the treatment of laterals." "Heavy pruning induces pitting unless heavy cropping prevents." "I left one tree *unpruned* in the middle of 2 acres of Cleopatras for ten years, and picked more clean apples from that one (in a bad season) than from ten of the heavily pruned trees." "We allowed the leaders of Cleopatra trees to remain last season, and these particular trees seemed to have rather less Bitter Pit."

In Western Australia every one is agreed that heavy pruning intensifies the disease, especially in young trees. "The harder the winter pruning the more prevalent the disease."

In Tasmania the larger number consider that severe pruning aggravates the disease. "I think the pruning has a lot to do with it. Trees that I pruned lightly and left all the laterals had less disease than those which were cut severely." "If a tree is allowed to go unpruned, and carry a heavy crop, there will be enough fruit to absorb the moisture and not show Pit."

INFLUENCE OF STOCK USED ON DISEASE.

In connexion with the stock used, a number of the growers are not in a position to offer an opinion, as the stock commonly used is Northern Spy, and few have tried other stocks.

In Victoria there are only eight of the growers who consider that the stock influences the disease, some from trying different stocks and others from the view that the Northern Spy stock encourages it. "I suspect the disease is affected by the stock used, since no apple is worse affected than the Spy, which is used almost exclusively for stocks." "Less Pit on Majetin stock." "Personally I favour the Five Crown seedling as a stock." "Have had Spy and Seedling stocks in same row and not noticed any difference." "I grafted a Cleopatra on a seedling I raised, and it is the worst tree in the orchard with Bitter Pit." "It appears to me as if the stocks on which varieties are worked and the methods of pruning if not the cause, are at least contributing factors." Mr. James Lang, of Harcourt, replies:—"All the old apple trees in my orchard are on seedling stocks, and they are as much subject to the disease as are those on the blight-proof stock. In the old orchards around Harcourt the trees were all worked on seedling stocks, but they are just as liable to the disease as on any other stock."

In New South Wales very few have tried working on different stocks.

In South Australia the few who have tried different stocks agree that they exert an influence on the disease. "By using a vigorous grower, such as Northern Spy or Strawberry Pippin for stocks, the liability to Pit is increased."

In Western Australia the effect of different stocks on the disease has not been tested.

In Tasmania the only reply concerning stocks states, "I have worked on blight-proof stock and seedling stock with the same results."

AUSTRALIAN-RAISED SEEDLINGS IN THEIR RELATION TO BITTER PIT.

There are a number of Australian seedlings growing in the Burnley Gardens, and their relation to Bitter Pit will be fully dealt with elsewhere; but, in the meantime, we are only concerned with the views of growers on this subject. Only a limited number have had experience of them, and they are either not particularly subject or take Pit freely. "In several instances they were pretty bad." "Colonial seedlings do not suffer more than others." "The seedling we grow, Mellon's Seedling, is almost free from Pit."

In New South Wales replies the only reference to Australian seedlings is—"I have only two seedlings bearing. They have no Bitter Pit."

In South Australia there is only one reply. "It depends entirely upon their origin whether particularly subject to the disease or not."

In Western Australia the only seedling apple referred to is Western Belle, "growing on its own roots, and, while winter pruned, was badly affected."

In Tasmanian replies no references made to Australian seedlings.

DISEASES IN FRUITS OTHER THAN APPLES AND PEARS.

In Victoria quite a large number of growers have never met with it in pears, and only four have recorded it in quinces.

In New South Wales two have observed it on quinces, and several have never seen it on pears.

In South Australia one grower notes it "in plums sometimes when trees cut hard."

In Western Australia quite a number have not met with it on pears, but six record it on quinces, and in some cases pretty bad.

In Tasmania several have observed it only in apples, and two in quinces.

DISEASES ASSOCIATED WITH BITTER PIT.

In Victoria the disease most frequently mentioned is "Black Spot" or "Scab," although one grower states, "I have often noticed that a tree infested with 'Black Spot' shows no sign of Pit." "Woolly Blight" is noted by several, and one remarks, "If the trees are bad with Woolly Aphis, then the Pit is worse."

In New South Wales Black Spot is only mentioned, and one records "Mouldy Core" in Cleopatra along with it.

In South Australia Black Spot and "Mouldy Core" are mentioned, and also "Woolly Blight." "Pit is generally worse on trees affected by Woolly Blight."

In Western Australia quite a number of diseases were found associated—"Black Spot," "Mouldy Core," "Water Core" or "Glassiness," "Bitter Rot," and "Woolly Blight." "Pit got bad after trees were badly affected with aphis."

In Tasmania "Black Spot" is the principal disease associated with it.

LOSSES SUSTAINED.

It is not an easy matter to estimate the loss caused by Bitter Pit in the orchard, since it is only certain varieties which are usually badly affected, while the general crop may give a good yield. In order to secure some definite data, the season of 1910–11 was the one chosen for estimating the loss. There were 55 out of 125 orchardists in Victoria who reported losses from that cause.

These varied from 5 per cent. up to 85 per cent., and sometimes, as in the case of Cleopatras, they were practically all affected. In susceptible varieties, one-half to one-fourth of the crop was given as a loss, and sometimes 75 per cent. of the Cleopatras would be affected, while only 5 per cent. of the other kinds suffered. The varieties specially mentioned as being badly affected were Cleopatra, Annie Elizabeth, Prince Bismarck, Sturmer Pippin, Williams' Favorite, Baldwin, Northern Spy, Shockley, and Lord Wolseley, and the loss sustained would be, approximately, one-half or one-third the crop.

In New South Wales only about one-fourth of the growers reported Bitter Pit as causing serious loss, and 25 to 50 per cent. of the crop affected. Cleopatra and Lord Wolseley were the varieties chiefly affected.

In South Australia 8 out of 21 growers reported losses. It varied from 10 to 50 per cent., one orchardist stating that over 30 per cent. of the Cleopatra apples were affected, and 12 per cent. of the general crop. Another orchard in the same district was absolutely free from it, and the reason assigned for its absence was "when pruning, do not top or cut apple trees back." The varieties mentioned as being badly affected were Cleopatra, Northern Spy, Dumelow's Seedling, Cox's Orange Pippin, Baldwin, Senator, Prince Bismarck, and Esopus Spitzenberg.

In Western Australia only five growers reported any loss, and it varied from 5 to 30 per cent., but in the Cleopatras it was worse. The varieties particularly mentioned as being affected were Cleopatra, Sturmer Pippin, Shockley, Jonathan, Winter Majetin, Lord Wolseley, Rymer, Stone Pippin, and Esopus Spitzenberg.

In Tasmania seven growers reported a loss, from 5 up to 30 per cent., 20 to 30 per cent. being about the average loss. The varieties principally mentioned as being affected were Cleopatra, Sturmer Pippin, Ribston Pippin, Hoover, Scarlet Nonpareil, Annie Elizabeth, and Wellington.

PREVALENCE OF BITTER PIT IN WET OR DRY SEASONS.

That a wet season favours the disease is the opinion held by the great majority of orchardists in Victoria. "Last season (1910–11) was absolutely the worst, which was a very wet season." "Disease is worse every very wet season, when the fruit is overgrown." "Sudden excess of moisture after dry winter will produce it. Not a consistent wet season." "The worst season was 1910–11, being wet; the previous season being dry, very few apples were affected." "Two things are certain, viz., the disease is worse (1) if it is a dry year; (2) if the crop be a light one."

In New South Wales some hold that wet seasons favour it, and others that it is more prevalent in a dry season. "Have not noticed any season worse than another. Whilst in the Wagga District we had dry seasons, and Pit was always present." "These last two seasons have been the worst, and one was wet and the other dry."

Mr. Edgell, of Bathurst, states that 1910–11 was his worst season, and gives the summer rainfall:—

December, 1910	2·76 inches
January, 1911	3·85 ,,
February, 1911	2·85 ,,
Total	9·46 inches

The average rainfall for eleven years was—

December	1·83 inches
January	2·04 ,,
February	1·04 ,,

so that evidently a wet summer season was most favorable in this instance.

In South Australia the prevailing opinion is that wet seasons favour the disease. "It was also bad in 1910–11 owing to the summer being cool and moist following a wet winter. Pit is rare in hot dry summers." This is the remark of Mr. Robin, of Nuriootpa, who gives the spring and summer rainfall for 1910–11, the average for the district being 21 inches :—

Spring—	
September	2·80 inches
October	2·50 ,,
November	1·81 ,,
	7·11 inches
Summer—	
December	1·94 inches
January	·27 ,,
February	1·73 ,,
	3.94 inches

In Western Australia the growers consider that wet seasons encourage the disease. One remarks, however, "all seasons practically the same, the rainfall being fairly even."

In Tasmania a few consider that a wet or dry season makes no difference, but the majority hold that wet favours it. "Wet seasons, certainly, together with light crops." "Wet winter and dry summer are the worst."

IS THE DISEASE INCREASING?

In Victoria the great majority of growers report that it is not increasing. Five consider that it is decreasing, 27 that it is increasing, and the remainder emphatically reply in the negative. "I think that it is increasing, assuming the same conditions of pruning, &c., are carried on, but people are beginning to prune longer, which tends to arrest the disease in some measure, so if these conditions are going to prevail, the answer would be *no*." "We notice it more now because we are growing more, but I think it was just as bad twenty years ago."

In New South Wales it is reported as not increasing, with the exception of the one district of Adelong. A good deal depends on the varieties grown, for, as one remarks, "it is largely a matter of the number of Cleopatras planted whether it is on the increase or not."

In South Australia eight consider it to be on the increase and thirteen that it is not so. "It does seem on the increase, but of late years there has been a lot of new varieties introduced." "It is not on the increase. We are getting it under by not pruning severely; but many orchards are bad where people insist on pruning hard."

In Western Australia there are only three growers who consider it slightly increasing, but many of the others report it on the decrease.

In Tasmania there are nine growers who consider it on the increase and fourteen that it is not. "Decreasing as trees get older and bear more heavily." "Increasing, but production and planting correspond."

CAUSES ASSIGNED.

In a subject like Bitter Pit, where neither insects nor fungi, bacteria nor mechanical agencies are concerned, there is plenty of scope for the exercise of the imagination, and quite a

number of theories have been propounded by growers to account for it. Some of the principal theories and opinions are here given:—

(*a*) Excess of sap is the most common reason given. Heavy rains after a dry spell cause a sudden flow of sap, and this abundant supply of sap may receive a sudden check. Excess of sap will produce overgrowth in the fruit, and in nearly every case it is the large overgrown apples which are affected. Uneven and irregular flow of sap is also mentioned, as in those cases where Pit occurs during dry seasons with occasional thunderstorms.—"I feel sure it is caused by too free a flow of sap, which, of course, may be caused in many ways, such as heavy pruning, strong growth of young trees, a wet spring, or heavy showers at long intervals during the end of the ripening season—anything, in fact, which causes a sudden or exceptional flow of sap." "My idea of Bitter Pit has been where trees have suffered in the summer with drought, then heavy rain falling has caused a rush of sap. I have irrigation for my orchard, and never let a tree suffer from want of moisture, then when rain comes there is no excessive rush of sap, and I suffer less than my neighbours, who trust to the natural rains. In fact, my loss is not worth mentioning." "Young trees are more subject to it than old. I find it less prevalent as the trees become mature." "After a close study for many years I have thought that it is caused through an irregular flow of sap. My reason for advancing this theory is, that one season part of an orchard that had a strong vigorous growth was left out in the early watering. After a spell of dry weather the trees showed signs of dryness, the water was put on, and the trees on that part had the worst attack of Bitter Pit I have known."

(*b*) Severe pruning.—"Trees bearing fruit on well-ripened wood are not affected, but if pruned heavily and a light crop of fruit on a vigorous growing tree, it is most likely to occur." "I think severe pruning causes a vigorous flow of sap which helps to develop Bitter Pit." "Extreme variations of temperature and excessive moisture are important factors in producing the disease. In pruning, great judgment is necessary. I consider that the modern method of training the trees to a very limited number of branches is responsible for a great deal of the disease, as the sap, being concentrated in a few channels, becomes too strong for the regular development of the fruit." "I am fully convinced that pruning has nothing to do with it, as six Cleopatra trees, twenty years old, I have growing in a gully have never been pruned, and they were as bad or worse than any tree I have got—as bad as the young Cleopatra trees five years old, which have been pruned." "We can only say that we know that hard cutting back of the leaders will produce apples badly affected. Our treatment is to cut the leaders very little, and, by a judicious thinning every year, we keep our orchard practically free of the disease." In this orchard there is a red sandy soil over red clay subsoil. "Less pit on apples grown on left laterals." "Slight benefit effected by leaving lateral growths." "If you prune hard you are liable to intensify it."

(*c*) Want of drainage and excess of moisture. "Where the land is wettest the Pit is worst."

(*d*) Unsuitable stocks.—"I think that if a change in the stock were tried it might be an advantage. The principal stock used is Northern Spy, and it is the worst affected with us." "I consider if the Winter Majetin stock was more in use there would be less Bitter Pit." Meier Brothers, of Kilsyth, Victoria, have a number of trees worked on seedling stocks, viz., Jonathan, Five Crown, Yates,

Reinette de Canada, Gravenstein, Duchess d'Oldenburgh, and Shorland Queen, and the effect of these stocks on the development of Bitter Pit is being observed.

(*e*) Over manuring or heavy manuring with stable manure.—"Heavy manuring with stable manure, and watering, with heavy pruning, cause the disease."

(*f*) Climatic conditions, such as a wet spring followed by a dry summer, or the shock caused by a sudden period of dry weather.—"Continued drought so that the trees begin to suffer, then a sudden and heavy fall of rain causing the trees to start a second growth will cause it at any time." "I thought at one time that it was due to excessive moisture, but that is not the case, as the past season (1910–11) was the wettest known here, and Annie Elizabeth, being generally the worst affected, were clean." "The conclusions I have come to are, that if you manure heavily with nitrogenous manures, and have a dry spell followed by heavy rains, you will get Bitter Pit, but if the season is fairly wet like last year (1910), so that there is no check to the growth, you have little or no Bitter Pit."

(*g*) Light crops caused by bad setting.—"I have never met an apple *absolutely* free, especially if a light crop with large fruit."

(*h*) Absence of lime or some other necessary chemical ingredient lacking in the soil.—"I have noticed that, where the soil and subsoil is calcareous, the most susceptible apples are comparatively free from Pit."

(*i*) Too much imperfectly prepared food and vegetable indigestion.—"Having noticed that Pit occurs—(*a*) on fruit of young trees; (*b*) when there is a light crop of large grown fruit; (*c*) on fruit from trees in rich black ground, and (*d*) on fruit on thick artificial spurs or spurs near a strong flow of sap, I am of opinion that the trouble is due to too much coarse or imperfectly prepared food."

(*j*) Nature of soil.—"Heavy soils badly worked and badly drained favour the Pit." "It seems to be constitutional with certain varieties of apples. If these varieties are planted on heavy wet soil Bitter Pit is always prevalent. If the same varieties are planted on light well-drained soil they are mostly clean." "I have trees growing on rich moist soil very badly affected, and, at the same time, the same variety growing on a poor ridge quite free."

The cause generally is well summed up in the following opinion from the Hon. T. Playford, one of the oldest fruit-growers of South Australia: "Bitter Pit is mainly, if not altogether, caused by a superabundance of sap in the tree, and of juice in the fruit. I first saw it in 1860. I have found it worse in Cleopatra, Northern Spy, and London Pippin. The early sorts are mostly free from it, except Gladstone. It always occurs in large fruit. I had two Cleopatra trees growing side by side, one with a good crop of moderate sized fruit, one with a small crop of large sized fruit; the smaller fruit, when stored, never developed the Pit, the larger were nearly all rendered unsaleable by it. This is a sample of my experience with all other kinds—it is the universal rule. This has caused me to come to the conclusion that the cause of Bitter Pit will be found in the sap of the tree and the juice of the fruit. It is not infectious—is not caused by insect pest or fungoid growth, so far as I have been able to ascertain."

REMEDIES PROPOSED.

In offering opinions on the probable causes of Bitter Pit, some of the growers have ventured to propose remedies.

Mr. A. G. Campbell, Pomonal, Victoria, writes—"Remedies practised with success by myself are drainage of black ground, light cultivation, even rolling of rich ground, and an open system of pruning with laterals to bear fruit."

Mr. J. Cockram, Ceres, Victoria, writes—"My own experience goes to prove that a light pruning, whereby the trees are induced to bear freely, will greatly minimize the trouble."

Mr. D. Puckle, Somerville, Victoria, writes—"The only way to help to ward it off in trees that are not more than eight or nine years old is to leave plenty of laterals on the outside of the branches, and so run the sap off."

Messrs. Trescowthick Bros., Angaston, South Australia, write—"Our treatment is to cut the leaders very lightly, and by a judicious thinning every year, we keep our orchard practically free of the disease."

Mr. J. F. Moody, Fruit Industries Commissioner for Western Australia, has forwarded to me a copy of a memorandum on the subject of Bitter Pit, submitted to his Minister on 23rd May, 1912. After saying "I was led to the definite conclusion that Pit is a sap trouble, caused by impurities in the sap setting up inflammation or irritation of the cells," he proceeds as follows:—"I found that by thorough draining, deep cultivation, heavy liming, and the use of plenty of potash, as well as a dressing of sulphate of iron, the soil conditions could be greatly improved, and impurities could be neutralized and carried out of the soil in the drainage waters. I also found that great benefits were derived from admitting plenty of sunlight, and permitting free circulation of air, by an open system of pruning."

The proposed remedies are sometimes worse than the disease. A Tasmanian orchardist brought under the notice of the Minister of Agriculture a remedy which he had found efficacious for Bitter Pit. It consisted of the application to the roots of the tree of carbonate of soda or washing soda, after the fruit had set, and a second application when the fruit was half grown. This is the principal ingredient in what are known as "alkali soils," and is not only injurious to the soil itself, but to the plants grown upon it. It bears the popular name of "black alkali," because it dissolves the humus-substance in the soil, and forms an inky-black solution, which may appear upon the surface in the form of black spots.

GENERAL CONCLUSIONS.

After carefully considering the replies received, there are certain facts borne out by the collective experience of growers. Of course, the greater the number, and the more representative the orchardists, the more value will be attached to their conclusions. But, in some of the States, only a small proportion availed themselves of the opportunity. Thus, in South Australia, out of 83 fruit-growers to whom the circular of questions was addressed, only 21 forwarded replies. Another common source of error, which renders the replies, in many instances, of little or no value, is that some general treatment is applied to the trees, in the way of manuring, or liming, or pruning, but no check trees are left untreated, to show what the result would have been without such special treatment.

The following facts may be considered as established from the reports received:—

1. That the disease is much more generally distributed among apples than pears.
2. That some varieties of apples are much more susceptible to the disease than others, Cleopatra being one of the worst, and Yates being least affected, if at all.
3. That the disease has been definitely known in Australia at least since 1886.
4. That the disease is worse on trees bearing a light crop and large fruit.
5. That severe or hard pruning favours the disease.
6. That the disease may occur in apples, pears, and quinces.
7. That the disease may appear in a wet or dry season, although the prevailing opinion is that wet seasons are the worst.

Mr. A. H. Benson, Director of Agriculture, Tasmania, conceived the happy idea of sending out a few practical questions concerning Bitter Pit, principally to the various Fruit Boards. Nine of them replied, and their answers are incorporated in the general analysis, but the results may be briefly stated.

If we eliminate the points on which there is difference of opinion, it is generally agreed that the principal varieties liable to Bitter Pit in Tasmania are—Cleopatra, or New York Pippin, Sturmer Pippin, Ribston Pippin, Scarlet Pearmain, Adams' Pearmain, and French Crab; that young and vigorous trees show it most; that the retention of the lateral branches, when pruning, tend to diminish the disease; and that the weather conditions most favorable to Pit are a wet summer, or heavy rain after a dry spell.

XVIII.—VARIOUS CAUSES ASSIGNED FOR BITTER PIT.

Almost every conceivable cause has been brought forward to account for this disease. It has been attributed to a mechanical injury, brought about by blown sand, to rapid evaporation of water from the surface of the fruit, to spraying with poisonous compounds, to insects, such as the Harlequin Fruit Bug or mosquitoes, to faulty or heavy pruning, to excessive or deficient manuring, to unsuitable stocks, to climatic conditions, to sudden change of temperature, to defective drainage, to irrigation, to overgrowth, to a spell of dry weather followed by a heavy rainfall, to bursting of sap cells, so that the sap escapes and oxidizes, to some natural tendency in the varieties affected, and, lastly, to fungi or bacteria.

These are all theories offered by fruit-growers and others, sometimes singly, and sometimes in combination, and they are being put to the test, in so far as they are likely to throw any light on the subject.

They may be briefly considered under a few general headings, so as to eliminate the unfit, and retain whatever may be thought worthy of further trial. In all these theories it will be observed that there is no reference to the structure and functions of the fruit concerned, and it is a fundamental principle of pathology, whether of animal or plant, that, in order to understand the abnormal or diseased, it is necessary to be acquainted with the normal, so that the consideration of the problem, in the light of what has already been stated as to the conditions and results of the ordinary vital activities of the apple and pear, may give a new turn to our ideas of the causes producing the symptoms of Bitter Pit.

The effects of manuring, pruning, stocks, irrigation, and different methods of cultivation, are being tested in an experimental way, and will be dealt with under their respective headings, and the following agencies will now be considered in so far as they influence the disease known as Bitter Pit:—

1. Mechanical agencies.
2. Unfavorable conditions of soil and climate (including heat and moisture).
3. Insects.
4. Fungi and Bacteria.

MECHANICAL AGENCIES.

The idea of blown sand causing mechanical injury to the fruit was suggested at the Cape, but this would evidently only cause mechanical injury, similar to that of the impinging of hail-stones, which has already been considered. It does not account for the deep-seated injury to the cells of the flesh, which in the case of Bitter Pit is known to arise from internal causes, and the exterior "pitting" is a consequence of that internal injury.

As regards the theory of rapid evaporation of moisture from the surface of the fruit causing the disease, this was the explanation given concerning some apples affected with Bitter Pit forwarded to the United States Department of Agriculture some fourteen or fifteen years ago. Mr. Robin, of Nuriootpa, South Australia, sent some specimens of Esopus Spitzenberg apples, badly affected with Bitter Pit, and the Chief Pathologist suggested that it might have been caused by sun scald, the hot sun having burnt the spots on the skin of the apples, upon which dew-drops had collected.

Massee (54) has shown that spotting of the leaves may be brought about by minute drops of water on their surface at a time when the temperature is exceptionally low, and the roots copiously supplied with water. A chill is thereby produced, which affects the underlying cells, and so causes the "spot." But Massee himself, in discussing Bitter Pit, does not explain it in this way, when the fruit of the apple is affected.

Lafar (47), in the English translation of his Technical Mycology, in 1898 attributes the "brown spotting" of the apple, that is the spotting of sound apples under the rind, to some mechanical action. Whenever the cells become ruptured, from the dropping of the apple from the tree, or pressure in packing or transit, for example, then the oxygen is afforded an opportunity to act on the exposed constituents of the plasma. The enzyme found in the apple by Lindet (108), in 1893, carries the oxygen to the tannin, and the result is that dark-coloured oxy-compounds are produced, which are precipitated on the cell-walls as a permanent dye. This view does not explain the development of the brown spotting while the apple is still growing, and attached to the tree, where external mechanical agencies are excluded, from the very nature of the case.

UNFAVORABLE CONDITIONS OF SOIL AND CLIMATE.

Since the fruit is the outcome of all those antecedent conditions which affect the healthy growth of the tree itself, it will readily be understood that the nature of the soil and of the climatic conditions will have an important bearing on the formation of properly-matured and fully-formed fruit. The temperature of the soil, together with the necessary supply of air and food and water through it, will be dependent largely on its character, whether of a light and porous texture, or heavy land, with too much clay, and the rainfall, drainage, irrigation, &c., will all have an influence on the result. In Germany it is stated by Sorauer (85) that it is most common on loose soil in dry years; the general opinion of growers there is that a wet summer, with little sun, encourages it. In England it is said to occur with alternations of sun and shower, and even with heat and drought, as in 1911. In Australia (as we have seen) the prevailing opinion is that a wet season favours the disease, although a few have found it in dry years.

Whatever interferes with proper root-action, whether soil or climate, will affect the water supply, and, since it is known that excessive transpiration is favorable to the production of "pitting," there is bound to be a close interaction between the tree and its non-living environment, resulting in a normal or abnormal growth of the fruit. Manuring, to supply any deficiency in the soil, pruning, to regulate the proper distribution of fruit on the tree, and methods of cultivation, to control the due supply of heat and moisture, will all tend to minimize the effect of otherwise unfavorable conditions.

INSECTS.

As showing how hopeless were the early attempts to account for this disease, and how superficial the efforts to connect cause and effect, the theory of insect punctures is a striking illustration.

The common Harlequin Bug (*Dindymus versicolor*), which is a native of Australia, and may be found at certain seasons in countless myriads on almost any weed, or even fruit, was *supposed* to puncture the skin of apples, to extract the juice, and cause the fruit to spot. It often causes

damage to ripe fruit, and recently has been found on maize, causing it to wither, but without leaving any marks at all. As early as 1892, Dr. Cobb (15) mentions the punctures of insects, such as the Harlequin Bug, as a probable cause, but in 1896 he stated definitely, "I am now of the opinion that the insect *Dindymus versicolor* is not the cause of this disease." Bitter Pit often occurs where there is no evidence of the insect, and this theory has now been given up.

But, although the Harlequin Bug was discredited, the theory of insect punctures and the injection of a poison into the fruit was not dropped. And this seemed to have a more scientific basis to rest upon, for Stigmonose, as it was called by Woods (120), was shown to be a disease of carnations, causing "spotting" of the leaves, and produced by the punctures of insects. The spots were mostly produced by Aphides and Thrips, and in making a section of the leaf, the sucking apparatus of the insect was found in the tissues.

In 1903, Dr. Cobb (19) called attention in the *Agricultural Gazette* of New South Wales to a disease common on apples, pears, and quinces, but less so in the last, characterized by irregularities of the surface and browning of the tissue beneath the skin. The illustrations given are identical with those of the pear (Fig. 18) and the apples in Plate VII. The disease is there named "Stigmonose," and, from the description and drawings, there is no doubt that, in the case of the apple, it is "Crinkle"—"A short distance under the skin there appears a layer of spongy brown tissue, characteristic of this disease as it appears in full-grown apples"—and, in the case of the pear, Bitter Pit—"from end to end the peculiar malformations are to be seen, though they are most numerous at the blossom end."

All the apple varieties affected were found to be infested with the so-called red spider, and that was then regarded as the probable cause. But it is interesting to note that, in a communication to me from Dr. Cobb, dated 17th April, 1901, the following remarks occur about Bitter Pit:—"The theory that gives me the greatest stimulus is that we have in Bitter Pit a kind of Stigmonose—that the starting point is some mechanical injury, such as an insect puncture, and one is driven to suppose the cause to be one that escapes ordinary observation. I have some pretty strong circumstantial evidence against the red spider as a cause of Stigmonose in apples. I have often thought of mosquitoes in this connexion, and I certainly should not overlook them in a search for the cause of Bitter Pit. I now recall the fact that an orchard I had charge of 25 years ago suffered most severely (on Baldwins) on the side next to a swamp that bred mosquitoes, but no recent opportunity has occurred for me to make any observations in this connexion." This mosquito theory has been recently revived by Dr. Greig-Smith (36), who considered that these pits might very well have been caused by the injection of fluid into the fruit by insects such as the mosquito. Their piercing apparatus would reach about as deep as the centre of most of these brown spots, and, moreover, these spots only grew to a certain size. The sterile nature of these spots and their limited growth fitted in with the injection theory, for if the disease were produced by microbes, one would expect the spots to continue growing. The deep-seated spots are not hereby accounted for, and in the very numerous sections of the surface of the apple leading to the spots I have never found any trace of the sucking apparatus of any insect. Nevertheless, experiments were carried out to test this theory. It is not such a simple matter as it looks to enclose an apple tree in mosquito netting, so that no insect will gain access to the tree before the fruit has set. In the first place the variety must be self-fertile, so that fertilization will occur in the absence of insect life, and, besides, in the still air beneath the net there may not be sufficient motion to scatter the pollen. Further, the rain might rot it, and hailstones pierce it, so that all these contingencies had to be guarded against. Trees of a convenient size of the variety Jonathan were chosen, and covered with mosquito netting and cheese-cloth respectively, and wire netted over to prevent the net being damaged by the weather (Fig. 110). A solitary apple grew on the enclosed tree, while those alongside, under normal conditions, bore freely, and it was removed on 6th March, 1912. The fruit was normal, but not too brightly coloured, on account of being deprived of a certain amount of light. There were a few distinct pits of a greenish

tint on the side opposite the principal coloration, and, to all appearance, Bitter Pit had developed (Fig. 59). But, on cutting it across, it was found that the depressions on the skin were due to a Looper caterpillar tunnelling beneath, and, where it approached the surface, there was a depression just as the surface soil might sink in when undermined. There was certainly no development of pit in the absence of mosquitoes in the solitary apple borne by the netted tree, but the mosquito theory does not by any means account for the facts, as already shown.

FUNGI AND BACTERIA.

That the disease is non-parasitic in its nature is now agreed upon by all competent investigators. The microscopic examination of hundreds of sections of pitted spots failed to reveal the presence of fungi. From the investigations of Wortmann in 1892 down to those of Pole Evans in 1909, it has been invariably found that neither fungi nor bacteria were concerned in it.

In 1904 I forwarded specimens of pitted apples for bacteriological examination to Dr. Bull, Bacteriologist of the Melbourne University, who reports as follows :—" My examinations of apples forwarded on 28th March were largely of a negative character as regards the causal relationship of micro-organisms to the diseased portions. Microscopic examination failed to demonstrate the presence of any specific form of organism, and bacteria were for the most part very scanty. Very few organisms developed on gelatine plates, and those present were principally moulds and chromogenic air organisms. It may be of interest to note that the specimens of apples have been kept in a cool room at a temperature varying from 32° to 45° C. since 28th March (four months). On examining them this morning I found that most of them had completely softened, and were covered with a copious growth of moulds, mainly *Penicillium glaucum*. Several of them, however, although in direct contact with rotten fruit and copiously powdered with mould spores from adjacent apples, were in a perfectly sound condition except for the presence of the original diseased spots. The noteworthy thing was that *the original disease had not progressed.* If the conditions were due to bacteria *per se*, it is extremely probable that under such favorable conditions for pathogenic action and re-infection all the apples would have been destroyed. The apples which survived were Jonathans, and a large green apple with mottled red streaks (label lost). Several New York Pippins were fairly sound."

Professor Farmer, M.A., D.Sc., F.R.S., of the Imperial College of Science and Technology, London, also bears out the same view in a letter to me, dated 16th September, 1909 :—" I had some apples sent to me to ascertain whether the disease was due to fungal or bacterial action. I came to the conclusion that there was no such infection, but that the disease is physiological, *i.e.*, intrinsically due to pathological death of tissues. But it seemed to me to be useless to continue the inquiry when we could not try experiments, which, in my view, alone were likely to lead to the full elucidation of the trouble."

Dr. Erwin F. Smith, of the Laboratory of Plant Pathology, United States Department of Agriculture, informs me by letter that " I have never studied very thoroughly the Bitter Rot of Baldwin fruit spot of apples, but the few examinations I have made led me to believe that it was not due to bacteria."

In Europe and America, Africa and Australia there is the same consensus of opinion that fungi and bacteria are not concerned in its causation. But there may be brown depressions on the surface of apples likely, on a superficial glance, to be mistaken for Bitter Pit, and which are found swarming with bacteria (Fig. 60). There are these important differences, however, from Bitter Pit, that the depressions are more of the nature of excavations, and principally that there is no browning of the tissue beneath the skin. These surface excavations are comparatively rare, as I have only found them in a few Lord Wolseley apples, and the causal relation of the bacteria will be determined next season if specimens are available.

Having passed in review the various agencies brought forward to account for Bitter Pit, the way is now clear for a consideration of other theories which more or less adequately explain it. And among these they may be narrowed down to a very few, which are the result of painstaking work, and which offer a reasonable solution of the problem. The first really scientific attempt was made by Wortmann (97) in 1892, in his article, entitled "Ueber die sogen. 'Stippen' der Aepfel" (on the so-called "stippen" or "spotting" of the apple). Then Zschokke (98) in 1897 confirmed and extended his work in "Stippigwerden der Aepfel" (spotting of the apple). Next Massee (54) made a slight contribution to the subject in 1906, in his "Apple Disease" in the *Kew Bulletin*, and finally Pole Evans (31) in 1909 gave the most plausible explanation and one which has received general acceptance in his Technical Bulletin on "Bitter Pit of the Apple." As a result of these various investigations, and with the additional knowledge gained of the minute structure and functions of the apple and pear, I will be able to give such a view of the origin and development of Bitter Pit as seems to me the most probable and most reasonable, and which will enable us, from the solid bedrock of established fact, to proceed to practical measures for its control, or, at least, mitigation.

Wortmann's paper leaves no doubt that he is dealing with the disease of the apple now known as Bitter Pit, both from the description of its general characters and the microscopic appearance presented by the internal brown spots. He states at the outset that it is extremely common, and, therefore, well known to the orchardist, and that it first appears at or subsequent to the ripening of the fruit. In Germany it only appears exceptionally when the fruit is on the tree, and then only in very liable varieties, shortly before the fruit is picked, and in overgrown specimens. He observed that in the contracted and browned cells there were small starch-grains, while in the surrounding healthy tissue they were either absent or very scarce. He arrived at the conclusion, as the result of his researches, that neither fungi nor bacteria are concerned in it, but that it is due to physiological causes. The spots did not originate at the surface and extend inwardly, but they arose as isolated patches in the pulp near the surface, and gradually extended to the skin, meanwhile blending with one another, and forming larger spots. In seeking for their mode of origin he found that they were always in direct relation to the branches or ends of the vascular bundles permeating the pulp, and that they first appeared as pale brown groups of cells directly adjoining the brown-coloured vessels.

He, therefore, came to the conclusion that the brown spots stood in direct relation to the conduction of water, and, indeed, with its diminution and final cessation, due to the plucking and storing of the fruit.

His experiments and observations led him to conclude that the death of the cells in these spots is due to the concentration of the sap, following the loss of water. This loss of water, by direct transpiration from the superficial cells, is soon followed by conduction of water from the deeper-seated cells, and the consequence is that the concentration of the sap occurs in the pulp cells adjoining the vessels. The acidity of the concentrated sap is considered to be the direct cause of the injury, and this injury is followed by the browning, through oxidation, of the cells, which have lost their water, and become dry.

Several factors may, therefore, enter into the problem of the formation of the brown spots.

1. *The Amount and Rapidity of Transpiration.*—This is influenced by the character of the epidermis, conditions of storage, &c. It is pointed out that if the epidermis is so constructed that it retards transpiration, Bitter Pit will be prevented or only appear late, whereas, if it is easily permeable, the pitting will be readily induced. The examination of the epidermis in liable and non-liable sorts bore this out.

That Bitter Pit is not directly dependent on the amount of transpiration is shown by the fact that a specimen of a variety subject to spot will shrivel without the appearance of spots if kept in a warm dry room. Hence the *gradual* concentration of the cell-sap is essential to the formation of typical spots. He suggests that, when there is very rapid loss of water, the acid of the concentrated sap has insufficient time to act.

2. *The Quality and Relative Quantity of Substances in Solution in the Cell-sap.*—The same degree of concentration of different solutions may not be equally injurious, hence the actual per cent. of water lost in liable and non-liable varieties may not stand in a direct relation to their susceptibility to the disease.
3. *The Conductivity of the Pulp Cells.*—It is a well-known fact that there are spotting and non-spotting varieties, and Wortmann found, as the result of experiments with peeled apples, that, in varieties subject to spot, there was relatively slow water-conduction. Water is given off at the surface, and the death of these surface cells may ultimately follow unless the loss is made good by water-conduction from the underlying tissues. This conduction is more rapid in some varieties than in others.
4. *The Specific Resistance of the Protoplasm of the Cells to the Injurious Action of the Concentrated Sap.*—The protoplasm of one variety is more susceptible or more resistant to external influences than that of another variety, and so it is highly probable that the protoplasm of the non-spotting sorts is more resistant towards the action of the concentrated sap than the spotting.

Wortmann concludes that the spotting of susceptible varieties cannot be entirely prevented, but since trees which are improperly cared for produce fruit of less resistance towards unfavorable influences of every sort, attention should be paid to general cultural conditions, and, above all, to rational manuring.

Zschokke (98), in 1897, continued the work of Wortmann, and critically examined it. He pointed out that the structure of the epidermis, as given by Wortmann, did not bear out his contention that the spotting sorts transpire more freely than the non-spotting, owing to the epidermis of the former containing more openings and rents. Also, that the loss of water more quickly and in greater quantity in the peeled non-spotting fruits did *not* point to more effective protection by the epidermis, but merely proved that, in consequence of *better* and *more regular* conduction of the flesh in the non-spotting sorts, more water was brought from the interior to the transpiring surface. We ought not to lay too much stress on the structure of the epidermis, for not only the number, but also the influence of the various openings on transpiration have to be considered.

He accepted Wortmann's conclusion that the death of the cells is brought about by the gradual concentration of the cell-sap, also that the spots arise in the neighbourhood of the vessels and especially at the ends of the bundles.

There are thus certain groups of cells favorably situated for the conduction of water towards the surface, which lose more water than others, and, therefore, perish sooner owing to the concentration of the sap. As a cause of spotting he adds another factor to those brought forward by Wortmann, viz., the unequal rate of water conduction in the interior of the pulp.

Massee (54), in 1906, received some diseased apples from Cape Colony, accompanied by the following explanatory letter from the Cape of Good Hope Government Commercial Agency :—
" I have taken the liberty of forwarding to you one box containing apples of various kinds, which have been grown in Cape Colony. You will notice that they are all disfigured with marks or spots, and I am informed by the apple judges that these marks prevent the fruit being of any commercial value. Would you kindly inspect them, and give me all the information that you

possibly can that will be of value to the fruit-growers of Cape Colony, as to what the spot or fungus is, what it is caused through, and what is the most effectual and cheapest remedy that can be employed in the Cape Colony to get rid of it."

These apples were affected with the disease known as Bitter Pit, although Massee dealt with it under the general heading of "Apple Disease," and the information required is just what is wanted in connexion with the present investigation. He decided that neither fungi nor insects play any part in the disease, but that it is of a purely physiological nature, being due to irregularities in the ripening of the fruit. He explained that the dead rusty patches of flesh were due to certain groups of cells being killed by fermentation commencing before the starch was converted into sugar, and this was owing to excess of temperature during the early period of ripening. He observed that the dead rusty patches occurred just beneath the skin, the reason being that starch is most abundant near the periphery of the apple, and almost absent towards the centre.

He sums up with a recommendation for the prevention of the injury as follows:—"The injury was due to the fruit being subjected to too high a temperature during the first period of ripening. The fact that the lower half of each apple that was buried in the packing material remained perfectly free from disease suggests that if the fruit was completely covered with packing material, so as to exclude the free access of air, no injury would be sustained."

Pole Evans (31) investigated the subject in South Africa, and published an account of his researches in 1909. He reviewed the more important literature on the subject, and added a valuable contribution of his own. After an exhaustive examination of the internal brown spots he failed to demonstrate the presence of either bacteria or fungi, and also excluded any external agency. He, therefore, as the result of his studies arrived at conclusions which were undoubtedly an advance on any of the views hitherto propounded, and can best be given in his own words. He only claimed that the present conclusions were merely put forward with a view of suggesting certain lines upon which apple-growers in South Africa should work, in order to minimize their losses from this trouble.

He sums up as follows:—"Bitter Pit is an abnormal spotting of the fruit of the apple. It results from the bursting and consequent breaking-down of certain cells of the flesh, due to too great internal pressure. This great pressure is set up by the external conditions to which the trees are exposed. These trees are not of themselves plastic enough to adapt themselves to their environment, and thereby regulate their physiological functions, with the result that abnormal forces are brought into play, with which the plant is unable to cope in the ordinary course of events. In consequence thereof abnormal physiology leads to diseased conditions. The main factors that are responsible for spotting are believed to be excessive transpiration during the day, followed by its sudden checking and complete abeyance during the night, when root action is still vigorous, owing to the warmness of the soil. Under these circumstances water accumulation takes place to such an extent in the cells of the fruit that an actual bursting of the cells may occur."

"Although the results obtained thus far are in the main negative from my study of this disease, I am unable to offer any great remedy for the evil, yet I can suggest lines upon which the apple-grower in this country should proceed if he is to succeed with the cultivation of his fruit."

These lines were suggested by the fact that during his investigations he found that those varieties which escaped Bitter Pit, and which showed immunity towards it, were those only which might be described as colonial apples. They had originated from seed sown in the country, and so he suggested that the same process should be repeated. "We have, then, to make a clean start in this country so far as our apples are concerned, and we have to raise South African seedlings in the localities in which we wish to plant our orchards. By this means alone it is firmly believed that the present difficulties will be overcome."

In the light of our present knowledge of the structure and functions of the apple, and of the different parts of the tree itself, let us now see how these various theories as to the cause of Bitter Pit stand the test.

First, the essential point in Dr. Wortmann's theory is that concentration of the sap, following the loss of water by transpiration, occurs in the pulp cells adjoining the vessels, and the acidity of the concentrated sap is the direct cause of the injury. He maintains that this can be easily proved by artificially concentrating the contents of the pulp cells by means of such re-agents as salt or sugar solutions. He produced a " spotting " of the skin, especially where it was punctured to allow of the ready access of the solution to the interior, but, as already shown, this has no relation to Bitter Pit. In fact, tap-water alone produced the most conspicuous " spotting," and Dr. Wortmann has failed to show that concentration of the sap will account for the internal brown spotting of the fruit.

Second, Dr. Zschokke agreed with Dr. Wortmann that the death of the cells occurs in the neighbourhood of the vessels, and is brought about by the gradual concentration of the cell-sap. But, in order to account for the irregular distribution of the internal brown spots, he added an additional factor to those brought forward by Dr. Wortmann, viz., the unequal distribution of the water in the interior of the pulp. Certain groups of cells more favorably situated than others for the conduction of water lost it more readily, and so the concentration of the sap and the consequent death of the cells occurred there earlier. There is no reason given here why one portion of the pulp should have a better or worse water supply than another.

Third, since Massee based his conclusions on the examination of specimens sent from the Cape, and not from observing the disease in the orchard, they have not the same wide significance as in the two preceding cases. He considered that the fruit had been subjected to too high a temperature at the period of ripening, and consequently certain groups of cells were killed by fermentation. He very ingeniously explained the occurrence of the rusty dead patches beneath the skin, because starch is most abundant towards the periphery of the apple, and so fermentation would begin there before the starch was converted into sugar. The disease as it appears on the trees is not dealt with here at all.

Fourth, the latest important theory is brought forward by Pole Evans, who ascribes the disease to the " bursting and consequent breaking-down of certain cells of the flesh, due to too great internal pressure." This internal pressure is supposed to be brought about by the accumulation of water in the pulp cells. Now it is difficult to see how the cells could be brought to the bursting point since they possess such a capacity for expansion, and even when stretched to their fullest extent the water can still exude. This will be made evident by one or two illustrative examples. When a leaf begins to wilt, it is owing to the failure of the water supply, and the cells become flaccid and collapsed. But when water is supplied in the form of rainfall or artificial watering, the leaf stiffens, owing to the cells becoming turgid and distended, like so many puffed-up little balloons. Of course, the excess of moisture here will be regulated by the amount of evaporation going on, but still the capacity for extension of the cells is great. However, even if transpiration is kept in check, as it is in the conditions under which Bitter Pit is supposed to occur, and there is great pressure exerted on the cells, exudation may occur, and the pressure be relieved, as in the case of " Glassiness." Pole Evans himself says of this disease, " it is undoubted evidence of water exudation under pressure. The cell sap fills the cells to overflowing, but, instead of bursting them, quietly diffuses through their membranes or walls, and then accumulates in the intercellular spaces." There is no evidence brought forward to show how the bursting of the cells bordering on the vascular bundles should occur at one part of the apple more than another, as the cell-walls press against each other, and thus prevent the rupture of the individual cells, or why the disease of Bitter Pit should originate just beneath the skin. It will subsequently be shown that it is collapse and not rupture of the cells which occurs in Bitter Pit.

XIX.—DEGENERATION OF APPLE TREE VARIETIES.

It is sometimes stated that Bitter Pit is due to deterioration or degeneration in the varieties subject to it, and it becomes necessary, therefore, to consider the supposed degeneration of varieties as one of the possible causes of the trouble.

Every now and again the subject of degeneration in cultivated plants crops up, which shows itself in the quantity and quality of the produce diminishing and individual varieties actually dying out. It is contended that when varieties have been cultivated for a considerable period their original vigour becomes reduced, a weakness due to old age sets in, and that the variety, like the individual tree, for instance, has a limited duration of life. We have to distinguish here between varieties which are propagated in a sexual way by means of seed, and such as our fruit trees which are mainly propagated in a non-sexual or vegetative way by means of buds or grafts. Our varieties of apple trees have originated as a rule from seedlings, and from the original tree, branches or buds have been taken to multiply it.

In the case of a favorite variety of apple, such as Jonathan, innumerable buds or grafts must have been taken from tree after tree, and thus the numerous progeny of this variety have descended from a single individual. And just as each individual has a limited duration of life, so it is argued must the variety which is just composed of the detached portions of one original tree. Some orchardists believe that the older varieties of apples are becoming more and more feeble, and that new varieties are required to replace them, and the Baldwin apple is a case in point.

Those who support the theory of degeneration are able to point to various cultivated plants which seem to bear it out. Thus the old varieties of potatoes, which were extensively cultivated and very prolific, are now no longer seen on the market, and even in cereals the good old sorts are being replaced by new ones.

In the *Gardeners' Chronicle* for 1875 the question was discussed—Do varieties wear out, or tend to wear out. And the two extremes are presented there of limited and unlimited duration of life. Thomas Andrew Knight, a distinguished President of the Horticultural Society of London, upheld the view that all varieties are of very limited duration, in opposition to Speechley's dictum that "Apples properly planted will retain their good qualities so long as sun and earth endure." Eminent botanists, however, such as Lindley and De Candolle, maintained that this rapid dying out did not occur, since there are so many old varieties which remain, the Ribston Pippins, for instance, being to all appearance as good as ever they were, and numerous varieties of great age, well known to the practical horticulturist, are still healthy and productive. In attempting to answer the question, however, a distinction must be made, as already pointed out, between varieties propagated by seed, purely bred and not crossed, and varieties propagated from buds, cuttings, grafts, tubers, &c. Dr. Asa Gray inclined to the opinion that the former did not tend to run out in time, since the older a race is the more reason it has to continue true, while the latter would probably do so. He sums up as follows:—"The conclusion of the matter from the scientific point of view is that sexually propagated varieties or races, although liable to disappear through change, need not be expected to wear out, and there is no proof that they do; also, that non-sexually propagated varieties, though not liable to change, may theoretically be expected to wear out, but to be a very long time about it."

Downing has a chapter on "Remarks on the duration of varieties of Fruit Trees." After referring to the popular notion that when a good variety of fruit was once originated from seed, it might be continued by grafting and budding for ever, he expresses the opinion that, practically, no

natural limits are set upon the duration of a variety. He admits that varieties are constantly liable to decay or become worthless, but he attributes it to—

1st. Grafting upon unhealthy stocks;
2nd. Carelessness in selecting scions for grafting;
3rd. Unfavorable soil and climate, deterioration arising from a want of constitutional fitness for a climate different from its natural one.

As an example of a long-lived sort the Winter Pearmain may be mentioned, which is one of the oldest apples on record, and, as shown by Hogg, is referred to as early as the year 1200.

The view of the continuity of the individual through all its various detached portions of buds and grafts is based on the assumption that they all retain the original characteristics unaltered, but there is a modifying influence introduced in the mutual action of stock and scion, and even the soil and climate may alter the fruit as regards size, colour, and taste.

After long continued cultivation there may be a failure or decline of varieties, not necessarily due to old age, but to a change in the environment, such as mode of cultivation and weather, and to a change in the character of the variety.

Conclusions drawn from annuals, such as wheat, do not necessarily apply to perennials such as apple trees and vines, so that the opinions quoted here will only apply to perennials. The Government Viticulturist for Victoria, F. de Castella, with both Continental and Australian experience, does not believe in "variety degeneration" with regard to the vine, for he writes:— "I cannot say that I know of any vine varieties which have degenerated from old age, although you have, no doubt, heard of the stupid theory which prevailed at one time in France that phylloxera was due to degeneration resulting from long continued propagation by cuttings. Some of the vines now cultivated in France are considered to be of great antiquity, and yet they are quite as strong as recently raised seedlings."

Mr. G. H. Johnston, of the Experiment Farm, Bathurst, New South Wales, has submitted the theory of "varietal degeneration" to account for Bitter Pit. He starts from the well-established fact that some varieties are more liable than others, and instances as worst affected Cleopatra and Annie Elizabeth. "These are only selected as types, but will be found to be varieties which have long been grown." Now Annie Elizabeth is a seedling raised by Messrs. Harrison and Son, of Leicester, and received a first-class certificate from the Royal Horticultural Society in 1866, so that the statement—"the wood now used for grafts may, I think, be considered as being of a great age"—does not apply. Various other seedlings might be mentioned as being very susceptible, and which are not of a great age, such as Lord Wolseley, originated in New Zealand, and Prince Bismarck, in Victoria.

Therefore the explanation offered—"that the trees, owing to their age and consequent weakening, become more liable to this breakdown of cells than others"—falls to the ground. But the propounder of the theory recognises that "senile decay" is not always at work, for young and lately constituted varieties produced from seed may be sometimes pit-liable and sometimes resistant. So that, finally, he comes to the conclusion that the degeneration of varieties through continuous propagation by cuttings without the intervention of a sexual generation is the cause of Bitter Pit.

While we have not sufficient knowledge of the life of perennial plants, such as the apple tree, to say definitely whether it is capable of unlimited vegetative growth, nor sufficient evidence to conclude that the constant repetition of the parent form by budding and grafting has a tendency to weaken the constitution of the tree, there is no evidence brought forward to show that the presumed weakening effect is responsible for the occurrence of Bitter Pit. We must distinguish between the life of the individual tree and the life or continuance of the variety—between old and young trees and old and young varieties. An apple tree, when grown under suitable conditions, may reach a good old age. In Bunyard's (103) "Apples and Pears," reference is made to very old

trees still healthy and bearing well. He states that many of the pears in the counties of Devon and Somerset are "certainly 150 years old, yet the trees are as healthy and lofty as English elms."

Apples are equally long-lived, and Hooper (107) describes and figures an old French Nonpareil apple tree in Nova Scotia, probably 150 years old, and during twenty years the amount of fruit from it has varied from two barrels up to sixteen, the average being nine barrels.

Those orchards planted here on comparatively poor sandy soil, on a good clay subsoil with ample drainage, are still flourishing, while some of those on deep alluvial or volcanic soils are dying out.

It has already been pointed out that a tree may be very liable to Pit, and yet to all appearance healthy, and even old age or senile decay is not necessarily favorable to the disease. I have selected some old trees in Victoria to show that they are rather remarkable for freedom from Pit.

The apple tree represented in Fig. 117 was planted about 70 years ago in the orchard now occupied by Mr. Bosch, Greensborough. It was the variety known as Devonshire Red Streak, and in 1891 it was re-worked to Rymer, and afterwards yielded several heavy crops. In season 1909–10 it bore 30 cases of export fruit, without any sign of Bitter Pit. A limb broke off with the weight of the fruit, and Mr. Bosch decided to graft Rome Beauty on Rymer, and that is the condition in which it was photographed on 13th May, 1912. The soil is a sandy loam, and the roots may go down to any depth, as there is no clay bottom.

The old apple tree of the variety Purity represented in Fig. 118 and growing at Bongamero, Cheshunt, was planted about 1848, thus making it 64 years of age. The owner of it informs me that it has borne consistently for many years, one side or one-half being heavily laden with fruit each alternate year, the other half the intervening year. He has picked as much as 56 bushel cases off the tree, although not nearly so much of late years as formerly, some large limbs having broken off a year ago. Nevertheless it yielded during season 1910–11 30 cases of fruit, after a fair number had fallen. It has been sprayed with arsenate of lead for a few years. Bitter Pit has not been observed in the fruit, although younger trees in the district were showing a good deal. The tree, notwithstanding its age, still looks healthy. The pear tree, represented in Fig. 116, growing in a lane off Collins-street, Melbourne, is over 50 years of age. It is covered with abundance of bloom in the spring, and last season produced a fairly good crop of healthy pears, which, however, were rather hard and unpalatable. The tree is deteriorating under the adverse influences of poverty of soil, unfavorable surroundings, and lack of attention.

A tree of the Rymer variety at Harcourt (Fig. 112), 40 years old, yielded this season 40 bushel cases of fruit free from Bitter Pit, and the Broompark pear, over 50 years old (Fig. 114), is still vigorous. The growing points of an old tree, such as Rymer or Broompark, are just as capable of development as those of a single year old tree.

Then if we take an old variety such as the Winter Pearmain, which is noted by Dr. Hogg as the oldest existing English apple on record, having been cultivated in Norfolk as early as the year 1200, and a lately constituted variety, such as Magg's Seedling, the younger may be bad with Bitter Pit and the older comparatively free.

It is desirable, however, to test the effect of crossing on some of our commercial varieties, and, while enthusiastic individuals have undertaken the work in a limited way, it is time that a beginning was made in some of our State Nurseries to see how far new and regenerated forms resist the Bitter Pit. Attention has hitherto been paid to the breeding of cereals and potatoes, and although it takes longer time to secure results in the case of fruit trees, there is no reason why it should not be attempted. Systematically arranged experiments, with regard to stocks and cross-breeding, are very much wanted, and although the results would not be available within the currency of this investigation, still provision could be made for their continuance. So that while

Mr. Johnston has not proved the connexion between degeneration and Bitter Pit, I heartily indorse his concluding recommendation—"Nurseries should be established, where definite crossing would be carried on, and the seedlings tested by fruiting under conditions which would make for the development of the disease."

XX.—GEOGRAPHICAL DISTRIBUTION OF DISEASE.

In the historical account of the disease already given, it has been shown that it occurs in Europe and Africa, Canada and the United States, and in Australasia. It has not been discovered in Asia, although it probably exists there.

In the United States this disease is very prevalent, and Dr. Galloway, Chief of Bureau of Plant Industry, writes as follows, under date 24th November, 1911 :—"Bitter Pit in apples and pears is quite common in the United States, especially in the western irrigated orchards, where conditions are probably more like those in South Africa and Australia than the conditions in the older orchard districts of this country, which are in humid climates. In the Western States Bitter Pit occurs, but in the humid moister part of the country certain fruit-spot fungi, especially the *Cylindrosporium* discovered by Brooks, are usually more prevalent than the true Bitter Pit."

In a recent investigation by Brooks (101), he has found the "fruit spot" not only on the apple, but also on the quince. A Phoma stage has been discovered for the fungus causing it, so that the name is now changed from *Cylindrosporium pomi* Brooks to *Phoma pomi* Passer. This disease has not yet been met with in Australia, but it is readily controlled by spraying, and there is thus a clear distinction between the "fruit spot" and the "fruit pit" of the apple.

H. T. Güssow, Dominion Botanist for Canada, writes, under date 25th January, 1912—"Bitter Pit in Canada is one of the most troublesome injuries known to fruit-growers. It is present in practically all localities. My acquaintance with this disease is not only confined to its presence in Canada, but I also know that it is widely distributed in Great Britain and other European countries."

Even in England the disease has been extremely prevalent during 1911, and it is worthy of note that the summer was exceedingly hot and dry.

XXI.—BITTER PIT AND ITS CONTRIBUTING FACTORS.

It is a recognised principle of pathology that the normal structure and function of the part or organ concerned should be first studied and understood as far as possible, and then the abnormal condition of the same may be satisfactorily dealt with. So the structure and functions of the apple and pear were carefully investigated, with the result that not only was there found a perfect system of vessels supplying the "core" and ramifying among the cells of the flesh, but also immediately beneath the skin a beautiful network of vascular bundles to regulate and equalize the distribution of nutritive material in the area where the most rapid and greatest amount of growth was normally taking place. This network will be found to play an important part in connexion with Bitter Pit. I have now described the characteristic features of the disease as exhibited not only in Australia, but in other parts of the world, and have reviewed the various agencies which were supposed to account for it, and it has been shown that neither insects nor fungi, bacteria nor external agencies, are concerned in it. Clear proof has been given that Bitter Pit is an internal disease due to internal causes.

Next, the various theories propounded to explain the nature and symptoms of the disease were considered in order to eliminate, as much as possible, unnecessary and irrelevant factors, and to narrow down the issue within reasonable limits. It will be sufficient for our present purpose to note the following as the principal causes assigned :—

1. *Acidity of the concentrated Sap.*—The first really scientific investigation of the trouble, which had long been known in Europe, was made by Professor Wortmann in 1892. His experiments and observations led him to the conclusion that the death of the cells in the brown spots was due to the concentration of the acid of the sap following upon the loss of water. In connexion with this theory, Dr. Wortmann (97) states that it can easily be proved by experiments in which the contents of the pulp cells are artificially concentrated. For this purpose he recommends salt or sugar solution in which punctured apples are placed, and he observes that in 24 hours sharply circumscribed spots are produced. But the mistake was made here, as had already been done in the case of citric acid (Fig. 57) of confounding superficial spotting with Bitter Pit, and this was strikingly shown in repeating his experiments with salt and sugar solution and tap water respectively.

I took mature apples of the Yates variety, which are known to be practically immune to Bitter Pit, and placed both punctured and unpunctured specimens in a 10 per cent. salt solution, the same strength of sugar solution and tap water.

Salt Solution.—In the unpricked specimen there was no change in 24 hours, but in the pricked specimen there was a slight discoloration of the skin around the punctures, the spots being about 5 mm. in diameter. The spots were sometimes isolated and sometimes run together, where the punctures were in the form of a cross, so as to extend to one inch across.

When cut across, the tissue beneath the spot is not discoloured, but spongy, crescent shaped, and extending to the depth of the punctures. The portion affected beneath the skin is readily detached from the surrounding tissue.

Sugar Solution.—In the unpricked specimen there was no external change, but the pricked specimen showed a slight discoloration around the pricks. The tissue beneath was practically unchanged.

Tap Water.—The most conspicuous spotting was produced by the tap water on the pricked specimen, the unpricked remaining quite firm, and without any change. Some of the punctures showed round discolorations up to 7 mm. in diameter, with very slight depressions or none at all. When cut across the tissue is seen to be more watery to the depth of the puncture than that surrounding it, and somewhat resembling "glassiness." The water had evidently penetrated the punctures, and displaced the air in the tissue affected.

2. *Bursting and consequent breaking-down of certain cells of the flesh due to too great internal Pressure.*—This was the conclusion reached by Pole Evans as to the cause in 1909, after an exhaustive histological and bacteriological examination. But it has already been shown that, while the pulp cells have collapsed in the Bitter Pit spots, there is no evidence of bursting, and further, the cell-walls pressing against each other would tend to prevent it.

3. *Spraying with poisonous Compounds.*—This was the theory enunciated by Dr. Jean White in May, 1911. It has not only been shown, however, that Bitter Pit had been known in Europe and America, as well as in Australia, before spraying fruit trees for pests was introduced, but badly pitted fruit has been obtained here from apple trees which were purposely left unsprayed. Experimental and chemical evidence was brought forward to disprove it, and historical evidence from Australia and other countries showed that the disease existed long before spraying with poisonous compounds was thought of.

4. *Absorption of Poisons through the Roots.*—This is the theory put forward by Professor Ewart in a paper read before the Royal Society of Victoria on 14th December, 1911. This theory is sufficiently disposed of by the analysis of pitted apples made by Mr. P. R. Scott, Chemist for

Agriculture. A State Committee was appointed to collect pitted apples from unsprayed orchards, and, on analysis, not the slightest trace could be found of either lead or arsenic or any other mineral poison.

As a result of the investigations and observations carried out in the laboratory and in the orchard, I will now discuss the factors which explain some of the different phases of Bitter Pit.

WHERE BITTER PIT ORIGINATES.

In the apple represented in Figs. 90 and 91, showing the network of vessels, there are a number of dark patches scattered here and there over it. These are the tough brown cells of the Bitter Pit which occupy the position where meshes of the net ought to be. They still adhere, whilst the ordinary pulp-cells were easily removed.

Again, the Lord Wolseley apple reproduced direct from the object itself (Frontispiece) was simply selected as a typical example of the pit, and, when the self-same specimen was cut lengthwise, it was found that the brown spots occurred directly beneath the skin. Then, again, a simple experiment may be performed of taking an apple—the Yates by preference, as there is no Bitter Pit naturally there—and with a slender glass rod rounded at the end making an indentation without breaking the skin. If the pulp is examined beneath the skin it will be found that in about ten minutes it begins to discolour, and in about twenty minutes it will have turned quite brown. In every case the discoloration occurs in the region of the network of vessels.

It is worthy of note that the brown spots are first formed in the zone occupied by the vascular net. Not only is there ocular demonstration of the fact in the position of the tough brown spots still adhering to the apple in which the network is shown (Fig. 90), but it is remarkable corroborative evidence, more particularly as the existence of the network was unknown when the statements were made, that several careful observers have independently located the earliest appearance of the brown spots in the same position.

Lounsbury (51), in his article on "Bitter Pit" in the *Agricultural Journal* of the Cape of Good Hope, states—"The seat of the trouble is beneath the skin, and on cutting down through a spot the flesh is found to be brown, dry, and tough for a distance about as great as the diameter of the spot. Similar masses of discoloured tissue are sometimes scattered through the flesh nearly to the core of the fruit, but *the trouble is usually confined within a quarter inch of the surface.*"

Again, Wortmann (97) remarks—"On cutting across spotted apples, the spots are rarely found more than two-fifths of an inch from the surface, and quite isolated. What generally occurs is this, that the spots in the interior of the fruit always originate more or less near the surface, and then are continued to the skin, gradually blending with one another and forming larger spots, according to the duration of the formation."

Sorauer, also, in his "Atlas der Pflanzenkrankheiten," shows the brown spots directly beneath the skin.

While the Bitter Pit is thus found in its early stages immediately beneath the skin in the zone of the vascular network, it is also well-known that it may occur scattered through the flesh, and extending even to the core. This will depend upon the stage of growth of the apple when the disease begins, as in the specimens of Pomme de Neige from Orange (Fig. 47), the brown spots started at an age when the core formed the principal part of the fruit. It will also depend on the continuance of the conditions favorable to it, when it extends along the vascular bundles towards the core.

WHEN IT ORIGINATES.

The earliest appearance of Bitter Pit in the apple was specially followed in the Burnley Horticultural Gardens, where there are 672 different varieties of apple trees under observation. Only vague answers were given by the orchardist as to the stage of growth of the fruit when the

disease first appeared. In the replies to questions it was generally stated to be when about three-parts to nearly fully grown, and only two orchardists observed it in an early stage of the fruit, one "when about the size of a large walnut," and another, "in bad cases, before Christmas, when the fruit is the size of a walnut."

The stage at which it appeared in the Gardens was found to be different for different varieties, although it was generally at the period when the fruit was half-grown or approaching maturity, and that is a time of rapid growth. Its earliest appearance was on 7th December, 1911, when it was observed on Garden Royal (almost ripe, but green), Washington (about two-thirds grown), Dartmouth Crab (about three-quarters grown), White Transparent (ripe), Borrowdale (nearly ripe), and Murray's Hawthornden (about half-grown). They are all soft-fleshed apples, with the exception of Dartmouth Crab and Murray's Hawthornden.

But the earliest of the season was forwarded to me from Orange, New South Wales, by the local inspector, dated 30th November, 1911. These specimens were of special interest, as the same trouble had previously been investigated by Dr. A. N. Cobb (15), and referred to under the heading of "An Obscure Disease of the Apple." They were of the Snowy Apple, or Pomme de Neige variety, a rapidly-growing, quick-maturing, and soft-fleshed apple. The disease had been present since they were the size of walnuts, and the discoloration of the flesh apparently started at the core. There are two possible ways in which the brown spots may adjoin the core and be scattered through the flesh, as well as appear beneath the skin. If the fruit is affected at an early stage, such as that shown in Fig. 74, when it is practically all core and very little flesh, then the brown tissue would necessarily adjoin the core, and further growth might leave it in that position. Or, if at a later stage it occurred beneath the skin, then the browning might extend inwards along the course of the vessels.

ITS OCCURRENCE TOWARDS THE "EYE" END.

In examining a number of pitted apples, one cannot fail to notice that the pits or depressions are not uniformly distributed over the surface, but that they are mostly on the upper half, and usually towards the "eye" end of the apple. This is a very suggestive fact, and when an explanation is attempted, it seems to throw some light upon the origin of Bitter Pit itself.

In the first place, it is found that the openings in the skin (stomata and lenticels) are much more numerous in the upper than in the under portions of the fruit. A Yates apple was dipped in a solution of caustic potash, which enabled the skin to be easily removed. A square centimeter of the transparent skin from the blossom and stalk end respectively was taken, and on counting the lenticels it was found that there were 81 in the former and 26 in the latter, or a ratio roughly of three to one.

Professor Brooks (9) also verified this in the Baldwin and Northern Spy apples. "A square centimeter was marked off on the stem half of an apple and another on the blossom half, and the lenticels counted on these areas. By averaging the results secured from ten Baldwins, the ratio of seven to four was obtained as that existing between the number of lenticels on the blossom and stem halves of the apple. On Northern Spies, the ratio was, approximately, five to three." The larger number of openings will necessarily allow more active transpiration to go on at the blossom than at the stalk end.

In the second place, chemical analysis has shown that there is less water in the flesh there, owing to the extra transpiration.

For purposes of analysis, apples of the Annie Elizabeth variety, about half-grown, were picked from a tree in the Burnley Gardens on 31st January, 1912. A pitted and a clean apple were chosen of practically the same size from the same tree, and divided lengthwise into three sections, one of which was further divided crosswise into an upper, an under, and a middle portion. After removal

of the core and the skin, the moisture in each was determined. The first results were obtained by drying in a water bath at 100° C., and of duplicates to those sampled after eight days results were obtained by the use of the vacuum oven.

Similar apples from the same tree, and plucked at the same time, were kept for eight days in a cool moist chamber, and similarly treated (table). Dr. Zschokke (98) had previously carried out similar experiments in 1897, and his results are also given for comparison—

TABLE XII.—ANALYSIS OF APPLES FOR MOISTURE IN TOP, MIDDLE, AND BOTTOM SECTIONS.

	Freshly Plucked.			After 8 Days.			In Vacuum Oven.		
	Top.	Middle.	Bottom.	Top.	Middle.	Bottom.	Top.	Middle.	Bottom.
	%	%	%	%	%	%	%	%	%
Annie Elizabeth—clean ..	85·50	86·23	86·12	85·68	86·74	86·92	84·89	85·62	85·67
,, ,, pitted ..	85·49	87·04	87·58	86·13	86·51	86·17	85·09	85·90	85·50
Champaigne Reinette—clean	85·18	85·39	85·82	84·79	85·14	85·28	..	..	..
Yellow Bellflower—clean ..	..	..	..	86·48	87·46	87·44	..	..	..

The water content of the apple is seen to diminish from below upwards, both when picked direct from the tree and after keeping in a cool place for eight days. On an average the difference in moisture between the lower and the upper section is from ·5 to 1 per cent., and that difference is sufficiently great to favour the development of pit at the crown end. In Annie Elizabeth, when freshly plucked, there is a greater difference between the moisture of the lower and the upper section in the pitted than in the unpitted, but after keeping, the distinction between the top and bottom disappears.

HOW IT ORIGINATES.

Its origin directly beneath the skin and its occurrence towards the eye end of the apple, where transpiration is most active, point to the vessels as being concerned in it, and we shall see that it is only when the vessels fail to supply the pulp-cells with the necessary moisture that they collapse and die, turn brown and toughen.

If we take, for illustration, a young and vigorous growing apple tree in bearing, as long as nourishment is supplied regularly and there is not too great a rush of sap, as well as no interference from pests, the growing fruit will develop properly. But if the weather is intermittent, or a spell of dry weather followed by heavy showers, especially when the fruit is approaching maturity, then there is a danger of the rapidly-growing pulp-cells becoming overgorged. It must be remembered here, as already pointed out, that the pulp-cells of the apple, when approaching maturity, only develop new cells to a limited extent, so that the increase in growth is largely due to the enlargement and development of the individual cells already existing. Also, the most rapid and the greatest amount of growth is necessarily taking place towards the periphery, and it is here that the vascular network envelops the pulp, so as to regulate and distribute evenly the water supply among the constantly and rapidly enlarging cells. The net must keep pace with the growing and expanding apple or the commissariat will become disarranged, and the stretching must not be too violent nor too sudden, otherwise all the meshes of the net may not be completely formed.

From the description already given of the structure and functions of the vascular network, it will readily be understood that when the pulp-cells are being suddenly enlarged by the rapid absorption of water, the net may not be able to form sufficiently fast to keep pace with the growing

cells. A mesh here and there will be left unfinished, and there the cells immediately adjoining will not receive their regular supplies of nourishment through the regular channels, and collapse, and death will ensue. It is the vascular network which controls the supplies, and if it fails to keep pace with the growing cells, then at these particular spots where meshes of the net are wanting the groups of cells dry up and die.

But it is not only an excess of water which may cause Bitter Pit, for it is well known that it may arise in a dry season, and shrinking and shrivelling of the cells may be due to drought. Instances will be given of its occurrence in both a wet and a dry season, and how a deficiency of water may cause it will now be explained. If the fruit was sufficiently nourished to approach maturity, and the supplies then began to fail, more water being given off at the surface than taken in by the roots, the outer portion of the flesh immediately beneath the skin would be the first to receive a check in the diminished supply. Even although the net was completely formed, wherever the mesh of the network of vessels failed in conducting water, there the adjoining cells would collapse, and the entire patch shrivel and become brown.

The prevailing opinion in Australia is that wet seasons combined with light crops favour the disease, but if it happens that the rainfall is so equally distributed that the crop is normal and regular, then there may be very little pitted fruit. Some, however, are equally certain that dry weather favours it, and as we shall see it may be associated with either dry or wet seasons, so long as they are intermittent in their character at the critical period of growth.

The apple tree would seem to thrive and grow luxuriantly with plenty of moisture, and it is only when dry spells intervene between heavy showers that it suffers. Darwin, in his "Journal of Researches," remarks about Valdivia :—"The town is situated on the low banks of the stream and is so completely buried in a wood of apple trees that the streets are merely paths in an orchard. I have never seen any country where apple trees appeared to thrive so well as in this damp part of South America ; on the borders of the roads there were many young trees evidently self-grown. In Chiloe the inhabitants possess a marvellously short method of making an orchard. At the lower part of almost every branch, small conical, brown, wrinkled points project ; these are always ready to change into roots, as may sometimes be seen where any mud has been accidently splashed against the tree. A branch as thick as a man's thigh is chosen in the early spring, and is cut off just beneath a group of these points ; all the smaller branches are lopped off, and it is then placed about 2 feet deep in the ground. During the ensuing summer the stump throws out long shoots, and sometimes even bears fruit. I was shown one which had produced as many as 23 apples, but this was thought very unusual. In the third season the stump is changed (as I have myself seen) into a well-wooded tree, loaded with fruit."

If we consider the conditions prevailing in other countries in a season when this disease is very injurious, it is found that they are most varied. The weather conditions play an important part, and, while in England during the past season the weather was so exceptional that it brought forth a lengthened correspondence in *Nature* and other scientific journals, the disease was at the same time extremely prevalent. The weather experienced during the summer and first half of the autumn of 1911 was exceptionally hot and dry, and there was a persistent, parching drought. Dry conditions are not always supposed to be associated with the prevalence of Bitter Pit, and, in order to get at the facts of the case as fully as possible, I made certain inquiries, as the following correspondence will show :—"In the issue of *The Garden* for 2nd December, 1911, I notice some observations by 'Scientist' on Bitter Pit in apples, and, as I am investigating this particular disease at present, I would be pleased to have further information on one or two points. He observes that the disease was extremely prevalent during the past year, and, since the past summer in England was exceptionally hot and dry, it would be interesting to know the rainfall during the maturing of the fruit in the orchard where the fruit of Tower of Glammis that was illustrated was grown.

Generally, with us the disease is worst when the weather is intermittent; when there is a dry spell followed by heavy showers, and it would be instructive to learn what rain occurred during the ripening of the apple, and when it fell."

The following interesting reply was forwarded by D. Elkins, The Gardens, Trewsbury, Cirencester, Gloucestershire (29) :—" I note in your issue for 9th March, page 119, that your Colonial correspondent, Mr. D. McAlpine, asks for any information concerning Bitter Pit in apples, and refers to the fruit figured in *The Garden*, 2nd December, 1911. He desires to know the rainfall during the maturing of the apples in the orchard where the fruit of Tower of Glammis was grown. As the apple figured was grown in these gardens, I have pleasure in giving him the rainfall during the maturing three months, viz., August, September, and October. We had a slight rainfall on the first five days of August, amounting to only 0·65; then there was no rain till the 21st. From then till the end of the month we had 0·72. In September, rain fell on ten days, with a total of 1·49. In October, rain fell on seventeen days, the heaviest on the 21st, when 0·75 was registered. The total for the month was 3·48. Our soil is a thin loam overlying the usual brashy limestone of the Cotswolds, and we soon suffer from lack of moisture. I think the trouble was due to the excessively hot summer, followed by the rains in the latter end of September and October, as the earlier varieties, such as Mr. Gladstone, Beauty of Bath, Lady Sudeley, &c., were not affected. I did not observe any spots until the October rains. We grow over 60 varieties of apples. The softer-fleshed varieties were affected most."

Clearly the conditions favouring the disease were a dry and hot spell followed by rain at a time when the most rapid growth of the flesh normally took place.

I am also indebted to "Scientist" (76), in *The Garden*, for a comparison of the temperature and rainfall for the past four years during the critical months in the formation of the fruit, viz., August and September, in an orchard with light and porous soil, where the disease manifested itself for the first time in a noticeable manner.

TABLE XIII.—COMPARISON OF TEMPERATURE AND RAINFALL FOR FOUR YEARS DURING AUGUST AND SEPTEMBER PRINCIPALLY.

		1908.		1909.		1910.		1911.	
		August.	September.	August.	September.	August.	September.	August.	September.
Mean temperature	degrees	59·9	56·0	61·5	54·5	61·3	55·7	67·1	59·1
Mean soil temperature, 1 ft. ..	,,	61·8	56·3	62·3	56·6	61·5	57·1	67·7	60·3
,, ,, ,, 2 ft. ..	,,	62·5	57·6	62·8	58·1	60·9	57·3	66·6	61·3
,, ,, ,, 4 ft. ..	,,	60·7	57·4	59·7	57·6	59·5	57·7	64·2	61·6
Rainfall	inches	3·18	1·29	2·16	3·42	2·16	0·60	0·62	1·01
Number of days of rain	..	14	13	13	20	15	4	6	9
Total rain, May to September ..	..	9·78 inches		13·64 inches		8·9 inches		5·73 inches	

If we confine our attention to 1911, the year in which Bitter Pit was most prevalent, and principally the two critical months of August and September, we find—

(1) That the rainfall was the least of any.
(2) That the number of days in which it fell was the fewest.
(3) That the total amount from May to September was also least.
(4) That the mean temperature of the air was the highest of any.
(5) That the mean soil temperatures, at 1, 2, and 4 feet respectively, were also the highest in every instance.

While the apple was growing and receiving the necessary nutrient fluid to enable it to grow, there would, under these conditions, be excessive transpiration, and this excessive transpiration would be associated with rapid growth.

In this case, the continued heat and accompanying drought began to prevent supplies reaching the peripheral network of vessels when the fruit was approaching maturity, and the consequence was collapse of the cells and subsequent browning and toughening.

All the conditions encouraging excessive transpiration are here, such as bright sunlight, a dry atmosphere, and a high temperature, and the porous soil would ultimately become too dry to keep up the supply, more water being given off at the surface than taken in by the roots.

It will be seen, therefore, that Bitter Pit may arise under different weather conditions, and may be brought about by the co-operation of different factors. The weather may be regular and steady in a direction which encourages excessive transpiration, or it may be fluctuating, and a dry spell suddenly followed by showery weather, at a season when the apple is approaching maturity and most rapidly growing, may prevent the regular expansion of the vascular network. The final result is the same, the collapse of patches of cells owing to the failure of their water supply.

The severity of the attack is shown by a correspondent in the *Journal of the Royal Horticultural Society*, London, March, 1912, in which it is stated that—" This disease has been very prevalent during the past year, not only in soft-fleshed varieties, in which it always occurs more or less, but also in the hard-fleshed ones, though to a less extent."

ORIGIN OF "CRINKLE."

The question is sometimes asked, " Why should the Bitter Pit only appear in spots, and not all over ? " Well, I consider that in the case of Crinkle or Confluent Bitter Pit it does appear all over, and the explanation of how it occurs will throw light on the question. We have already seen that Bitter Pit may occur either when there is an *excess* or *deficiency* of moisture at a critical period of growth. When there is excessive moisture, and the enlargement of the pulp cells is too rapid to allow the vascular net to be formed regularly, then, wherever the supplies fail, the cells will ultimately collapse and die. But when there is insufficient moisture to enable the conducting tissue to supply all the cells towards the periphery, then a similar result will follow.

Now, in the case of Crinkle, the browning and toughening of the cells is produced over a large area, just beneath the skin, and the large and numerous cavities formed, with the consequent folding and depression of the skin, are indications of the sudden failure of supplies after a rapid rush of growth.

Finally, it is evident from this view of the origin of Bitter Pit, that the disease is not confined to one country, but probably exists wherever the apple is grown, and that it dates back to a very early period in its history. Even in Victoria, where apple trees have only been grown for about 70 years, the disease was known 35 years ago under the name of " Measles," and sometimes of " Small-pox " of the apple, and in South Australia, where there are some Cleopatras over 50 years of age, it has been known since 1868. In the older countries of the world, it has also long been known, although at first without a definite name to distinguish it, and I am indebted to Mr John Osborne, of Tasmania, for the following reference dating back to the twelfth century :—Richard Neckham, a prolific writer, who flourished about the middle of the twelfth century, mentions what was then called " a serious disorder of ye apple which is like unto a blister drying up under ye skin and givith ye fruit a taste that is bitter and unwholesome to the palate "—a condition much akin to the Bitter Pit of the present day.

CONTRIBUTING FACTORS.

The scientist and intelligent orchardist alike have come to the general conclusion that " it has something to do with the sap," although that very enigmatic statement may be interpreted in a variety of ways. It must never be forgotten that our fruit trees are grown under artificial conditions,

and that the cultural methods adopted to produce a large-fleshed juicy apple have had an injurious influence on the constitutional vigour of the tree. The study of fruit trees in all their bearings is just as necessary and just as important, from the point of view of the producer, as that of the wheat-plant or other cereals.

The principal factors which contribute to the development of Bitter Pit appear to be—(1) intermittent weather conditions when the fruit is at a critical period of growth; (2) amount and rapidity of transpiration; (3) excessive transpiration during the day followed by its sudden checking at night, when the roots are still active, owing to the heat of the soil; (4) failure of supplies at the periphery of the fruit, followed by spasmodic and irregular recovery; (5) inequality of growth, so that the vascular network controlling the distribution of nutritive material is not regularly formed; (6) fluctuations of temperature when fruit is in store; and (7) nature of the variety.

How far the result is affected by such factors as cultivation and drainage, manuring and pruning, stocks and irrigation, has yet to be determined by means of observation and experimental tests. The transpiration of a tree is known to be influenced by the heat of the soil in which its roots are embedded, increasing as the soil is heated, and diminishing as it becomes cooler. All those agencies, therefore, which influence the temperature of the soil in any way will be worthy of consideration. It is well known that a closely-packed moist soil is a much better conductor of heat than a loose dry soil. Hence frequent cultivation, in which the surface soil is kept dry and loose down to the depth in which the feeding roots are situated, would lower the temperature during the day in comparison with that of the same soil left uncultivated.

Whatever explanation be accepted as to the cause of Bitter Pit, there are always some varieties, such as Yates, to be accounted for, which are not subject to the disease under conditions most favorable to it, and are practically immune.

It is invariably puzzling to the orchardist, why one variety should escape the pit, and another tree growing alongside should be badly affected; why some apples in a cluster should be free, and the rest badly pitted; why, in short, one should be taken, and the other left.

Well, although it does not explain, yet it renders the phenomenon less obscure when we consider that no two objects are alike in living nature. No two beings are exactly alike, even in the case of twins; no two leaves of the same tree resemble each other exactly; no two seeds of the same plant are ever identical; and the seeds of the same plant from the same fruit never reproduce exactly the parent plant. It will be understood, therefore, that no two trees, even of the same variety, are identical, and may vary considerably in their root-system, their leaf surface, and their general constitutional vigour. It will be instructive to compare two varieties, such as Cleopatra and Yates—the one exceedingly liable to the disease and the other immune or practically so—in order to discover if there are any peculiarities in their structure to account for the difference, and this will be done during the coming season. When one considers the delicate adjustments necessary between the constantly enlarging network of vessels on the one hand, and the growth of the pulp-cells on the other, it is rather surprising than otherwise, that the fruit is so generally well-formed and shapely. The Yates is a slowly maturing apple, and one of the last to ripen, so that the growth at the periphery goes on in a regular and orderly manner.

PRACTICAL APPLICATIONS.

It is easy to show how the above explanation accounts for a number of the observed facts coming within the experience of the orchardist. When a tree is young and vigorous and making rapid growth, it is generally agreed that, at that stage, it is very subject to pitting, and the first crop is often very bad. The conditions are such as to favour rapid transpiration, and the excessive growth will tend to interfere with the regular development of the vascular network equally at every portion of the circumference. It has also been observed that, generally, there is more pit in a light crop than in a heavy one, especially when the fruit produced is somewhat abnormal in size.

Here, again, each individual apple of the lighter crop has received an extra supply of nutriment, and the over-gorging of the pulp-cells will tend to prevent the network being equally formed at the periphery, where the most rapid and greatest amount of growth is taking place. It has sometimes been pointed out to me that it is not always the largest apples on a tree which are affected, for in a cluster the small apples may be pitted and the larger ones escape. But it must be remembered that, while the general rule holds, there may be modifying factors to account for the exception. It is recognised by every orchardist that in a cluster of fruit it is the topmost or central one which shows the greatest amount of growth, yet in Fig. 20 I have shown a cluster of pears where the topmost one is the smallest. This exceptional occurrence could easily be explained, but an isolated instance does not interfere with the general principle.

Again, it is noticed by the observant orchardist that the more quickly-maturing apples on the tree are most liable to pit. In picking apples, especially for the oversea market, it is customary to go round the tree and select those which are most developed and of uniform size, leaving the others to mature. After a few weeks, under ordinary conditions, it is found that the smaller ones have grown bigger, and it is known by experience, as well as the result of the sales, that these are not so liable to develop pit. Further, it is sometimes observed that an older tree, especially when growing on a headland and left uncultivated, may be comparatively free from pit, while adjoining trees well cultivated and cared for may develop it. But it is evident here, from the conditions of the case, that there is not that stimulating and vigorous growth which would produce excessive transpiration and the undue development of the fruit.

Finally, reduced transpiration may be dependent on the nature of the fruit, and circumstances which would escape the observation of the ordinary orchardist. If a young Cleopatra apple, for instance, is carefully examined, it will be found that it is enveloped by a dense covering of hairs. This woolly covering protects the surface from the currents of air which sweep over it, and tend to dry it up. The compact hairy felt renders the air stagnant over the pores, and thus reduces the amount of transpiration. This principle is also well illustrated in some grasses, which develop a dense covering of hairs when growing in exposed situations, as on mountain tops, while in sheltered situations, as in valleys, the same grass may be destitute of hairs.

No doubt this hairy covering has something to do with the comparative freedom from pit of the quince, which is covered with hairs even to maturity, while the apple loses its hairs when it has reached the size of a walnut. Young Cleopatra apples were obtained from Burnley Gardens on 14th November of the size of hazel nuts and walnuts. On close examination the hairs were found to have fallen away, except around the base of the stalk and just at the "eye." After the fruit has set and the petals have just fallen, it is covered with a dense mass of hairs.

To regulate and control the transpiration is one of the most important factors in preventing the development of Bitter Pit. To this end the addition of humus to the soil by green manuring, light pruning so as not to reduce the transpiring surface too much, cultivation by keeping the soil at a more uniform temperature by night as well as by day, drainage to keep the temperature more even, liming to improve the physical condition of the soil, and by applying water at the right time and in proper proportions by means of irrigation, will all tend to make the growth of the fruit regular and even.

The experiments now being carried out, as detailed in Section XXII., will deal with all these factors, and show, as far as possible, in the limited period of the investigation how far, individually or collectively, they have a controlling influence upon the development of Bitter Pit.

REMEDIAL MEASURES.

It is rather premature to suggest remedial measures until the results of experiments now being conducted are known, but the practical conclusions drawn from the experience of German orchardists may be given. These were obtained from 107 replies to questions, and they were

published in April, 1909, in "Der praktische Ratgeber im Obst und Gartenbau" (6). The recommendations are justified from what we know of the disease in Australia :—

1. Light pruning, taking care to admit light at the top.
2. Thinning not to be overdone.
3. Growth not to be stimulated by fits and starts in the growing period, and water or liquid manures not to be applied too late in the autumn.
4. Not to pluck the fruit too late.
5. Not to have the store-room too dry.
6. To re-work, that is, to graft another variety on the old stock.

XXII.—EXPERIMENTS WITH A VIEW TO CONTROLLING THE DISEASE.

Since the investigation of Bitter Pit is conducted with the twofold object in view of determining the cause and devising a remedy, there have necessarily been researches in the laboratory as well as experiments and systematic observations in the orchard. From an investigation of the minute structure of the apple, and particularly from the discovery of the wonderful network of conducting tissue in the apple, pear, and quince, a flood of light has been thrown on the cause of Bitter Pit, and not only on this disease but several other obscure diseases of "pip fruits." The lines along which experiments are being conducted in the different States of the Commonwealth, chiefly with manures, pruning, various modes of cultivation, irrigation, and the employment of different stocks, are not only promising, with reference to the mitigation of this particular disease, but they cannot fail, from the varied conditions under which they are carried out, to be of great indirect benefit to the apple-growing industry as a whole.

As my official appointment only dates from August, 1911, it was rather late in the season to carry out some of the experimental work in a proper manner. Nevertheless, Experiment Stations were secured in the different States, with the exception of Queensland, which did not at first join in the investigation with the other States, but arrangements have now been made whereby this omission will be rectified.

Experiment Stations are now established in Victoria at Burnley Horticultural Gardens, Box Hill, and Deepdene ; in New South Wales at Bathurst Experiment Farm ; in South Australia at the Government Experiment Orchard, Blackwood ; in Tasmania at a Tamar River Valley orchard ; in West Australia at Mount Barker Estate ; and in Queensland at Stanthorpe.

The series of experiments include the following :—

A.—Manurial.
B.—Pruning.
C.—Stocks.
D.—Cultivation.
E.—Irrigation.
F.—Cold Storage.
G.—Miscellaneous.

Under each of these headings, the work done and the results obtained for one season will be recorded, but it must always be understood that no final conclusions can be drawn from such a limited experience. From the very nature of the work, these results will only supply a basis from which, as a starting point, the value of future experiments will be determined.

The variety of conditions under which these experiments are conducted—of soil and climate, heat and moisture, from Tasmania in the South to Queensland in the North, from New South Wales and Victoria in the East to Western Australia in the West—will supply valuable data as to the effect of environment on the prevalence of the disease. Since the conditions under which the results have been obtained are so important, I have endeavoured in this first Report to give in connexion

with each experiment station the nature of the soil as determined by chemical and mechanical analysis, the rainfall and the drainage, the mode of cultivation, and the system of pruning adopted, age of trees, together with the altitude and such other details as will enable any orchardist to form a clear conception of the accompanying conditions in each case.

Now that an insight has been gained into the factors which contribute to the development of this disease, efforts can be directed towards the discovery of preventive or remedial measures, which will not only enable the fruit to be gathered from the tree without the unsightly "pit," but also to insure that when the fruit is packed clean it can be exported without any development of the disease on the voyage.

We cannot control the weather, so we must turn our attention to the soil and the tree itself, which are capable of being controlled to a large extent. As regards the soil, there are three principal methods employed. By means of tillage or cultivation, the soil can be pulverized and rendered more suitable for plant-growth, weeds can be kept down, and a mulch formed to decrease the loss of water by evaporation. The heat of the soil may also be regulated to a certain extent. Rotation of crops is another means employed, but with fruit trees green manuring takes its place, by adding humus to the soil and thereby rendering it more retentive of moisture and more absorbent.

The application of fertilizers is also a well-known method of improving the soil physically, chemically, and biologically. Lime, for instance, improves the physical texture of the soil, acts chemically by liberating potash and neutralizing acidity, and it has a biological effect by encouraging certain classes of bacteria.

Irrigation may also be added as a means of control over the supply of moisture in the soil.

All these agencies are employed in the experimental tests now being conducted in connexion with Bitter Pit.

In the case of the tree, control may be exercised by selecting the varieties to be planted, by using the stocks best suited to the variety, and by the adoption of suitable methods of pruning. Cold storage has an undoubted influence on the keeping quality of the fruit, and all these measures must be tested in an experimental way.

A.—MANURIAL EXPERIMENTS.

For manurial experiments in connexion with Bitter Pit, it is necessary to have a sufficient number of trees of a liable variety, similar in age and size and all in bearing, planted in soil fairly equal throughout. It is not always easy to secure such conditions in an ordinary commercial orchard, but they must approximate to this standard in order that the results may be comparable.

It is desirable to have at least eight or ten trees in each plot, and there must be a barrier or guard plot on each side to prevent the intermixing of the manures from the spreading of the roots.

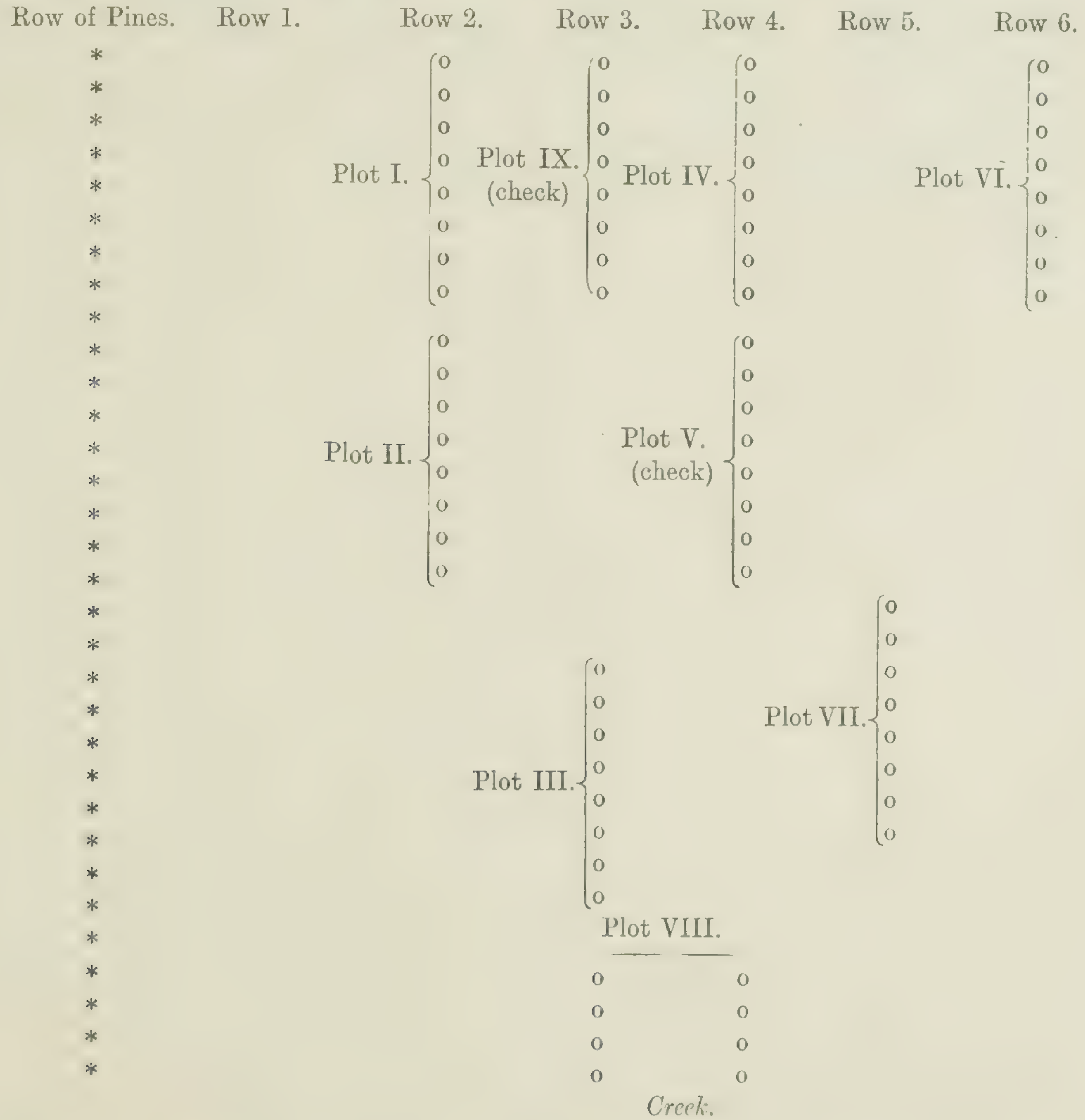
Since the fruit is mainly nourished from the food supply already stored up in the fruit-buds and other portions of the tree, it is evidently misleading to draw conclusions from the effects produced on the fruit by one season's application of manures. Only in the case of quick-acting manures, such as nitrate of soda, is any effect produced in the season during which it is applied.

The effect of sulphate of iron has been tried on Cleopatra apples in a Goulburn Valley orchard. It was used at the rate of 3 lbs. per tree, but, although it gave a deep-green healthy colour to the leaves, with an extra good yield, there were pitted apples on all the trees, and the disease developed further in store. Mr. W. L. Summers informs me that the Director of the Botanic Gardens, Adelaide, found much less pit after applying 2 to 3 lbs. of sulphate of iron per tree. This salt is being used by itself and in combination in the different manurial experiments.

1. At H. H. Hatfield's Orchard, Box Hill, near Melbourne.

This orchard, being only about 10 miles from Melbourne, was very conveniently situated for experimental work, and the generous offer of Mr. Hatfield to place it at my disposal was much appreciated. It is situated at an altitude of 317 feet above sea-level, with an easterly aspect. There were several rows of Esopus Spitzenberg, about fourteen years old, suitable for the purpose. Eight trees were chosen for each plot, and, as other varieties were grown among them, it was necessary so to arrange the plots that the eight experimental trees were together.

The following is the plan of the arrangement :—



The trees were planted 17 feet × 12 feet, or 213 to the acre, and they bore well in 1910-11. They had all been green manured, peas having been planted in June, with 2 cwt. of superphosphate to the acre to make them grow, and they were ploughed in when in flower in October. The soil is a medium loam, with a good clay about 18 inches beneath the surface, and it is drained with 2-in. pipes 3 feet deep.

Samples of soil for analysis were taken from top, middle, and bottom of orchard, and designated respectively "A," "B," and "C." This was the natural soil that had never been cultivated or manured.

CHEMICAL ANALYSIS OF SOILS.

—	No. 1 A. Soil Surface to 12″.	No. 2 A. Sub-soil, 12″–24″.	No. 1 B. Soil Surface to 12″.	No. 2 B. Sub-soil, 12″–24″.	No. 1 C. Soil Surface to 12″.	No. 2 C. Sub-soil, 12″–24″.
	%	%	%	%	%	%
Nitrogen	·064	·084	·053	·062	·050	·022
Phosphoric Acid	·029	·030	·027	·026	·022	·029
Potash	·078	·209	·058	·238	·104	·178
Lime	·059	·065	·081	·085	·037	·045
Magnesia	·102	·244	·089	·253	·133	·156
Chlorine	·025	·040	·020	·050	·030	·055
Reaction to Litmus Paper ..	Slightly acid	Slightly acid	Slightly acid	Slightly acid	Slightly acid	Slightly acid

MECHANICAL ANALYSIS OF SOILS.

—	A 1.	A 2.	B 1.	B 2.	C 1.	C 2.
	%	%	%	%	%	%
Very coarse sand (2–1)	2·30	0·60	0·40	0·45	0·00	0·00
Coarse sand (1–·5)	4·30	1·30	0·70	0·65	0·30	0·40
Medium sand (·5–·25)	3·55	1·20	0·95	0·70	0·35	0·35
Fine sand (·25–·1)	10·50	3·80	12·30	7·30	6·35	5·55
Very fine sand (·1–·05)	35·10	14·45	41·75	26·05	49·10	35·90
Silt (·05–·01)	3·35	4·85	4·70	6·80	4·35	8·60
Fine silt (·01–·005)	9·15	5·00	9·35	7·30	10·80	8·65
Clay (·7–·005)	26·24	58·23	25·41	42·10	24·10	35·28
Moisture	1·30	3·32	0·96	3·60	1·21	2·15
Loss on ignition	4·21	7·25	3·48	5·05	3·44	3·12
The soil contains	17·0 stones	Nil	3·0 stones	4·0 stones	Nil	Nil

The manure was applied on 18th August, and spread broadcast at a distance of fully 4 feet from butt of tree (Fig. 120). It was then hoed in, and the first rains washed it down.

The cultivation consisted in ploughing the orchard, as a rule, after the fruit is picked, and allowing the weeds to grow. Then towards the end of May or early in June, according to the season, peas are sown with 2 cwt. of ordinary superphosphate to the acre. The peas are usually ploughed in during October. Two ploughings are thus given each year, and the ground is kept as clean as possible while the fruit is on the trees, by harrowing and stirring the soil when necessary. Of course, in the experimental plots green manuring is no longer carried out, except on those specially set aside for that purpose.

The rainfall in orchard for 1911 was about 36 inches, and distributed as follows:—

Month	Inches.	Month	Inches.
January	·64	August	1·18
February	5·15	September	1·79½
March	8·80	October	2·51
April	1·03	November	·49
May	3·50	December	3·54
June	4·96	Total	35·91
July	2·32		

The rainfall for the first three months of 1912 was as follows, and the apples were picked on 29th March :—

	Inches.
January	·74
February	1·52
March	·62

All the trees were treated alike as far as spraying is concerned. Just as the buds began to open, they were sprayed for "Black Spot" with a mixture consisting of 7 lbs. bluestone and 5 lbs. freshly slaked lime to 50 gallons of water, with 4 lbs. alum added. Then they were sprayed with arsenate of lead for the Codlin moth three times, viz., 12th and 23rd October and 22nd November.

TABLE XIV.—RESULT OF FIRST YEAR'S MANURIAL EXPERIMENTS WITH ESOPUS SPITZENBERG, AT MR. HATFIELD'S ORCHARD, BOX HILL.

Plot No.	Manure.	Per Tree.	No. of Trees.	Yield of Marketable Apples.	Pitted.	Percentage of Pitted to Clean.
		lb.		lbs.	lbs.	lbs.
1	Sulphate of ammonia	½	..	1,020	5½	·54
	Ordinary superphosphate	1½	8			
	Sulphate of potash	½				
2	Sulphate of ammonia	½	..	610	1½	·24
	Bonedust	½	8			
	Ordinary superphosphate	1				
	Sulphate of potash	½				
3	Sulphate of ammonia	½	..	813	12½	1·5
	Ordinary superphosphate	1½	8			
	Kainit	2				
4	Ordinary superphosphate	1½	..	893	2½	·28
	Sulphate of potash	½	8			
	Green manuring every alternate year					
5	No artificial manure—check..	..	8	440	6	1·3
6	Slaked lime	2½	8	860	5¼	·61
7	Ordinary superphosphate	1½	8	888	6	·67
	Sulphate of potash	½				
8	Ordinary superphosphate	1½	8	644	1	·15
	Sulphate of ammonia	½				
9	No artificial manure—check	..	8	600	27	4·5

This is a remarkably small percentage of Bitter Pit on the trees, but this variety is generally supposed to develop it mostly in store. However, in another portion of the orchard, where there was a much smaller crop, there was over 17 per cent. on the trees. Six trees of the same variety were selected for comparison and picked at the same time. The yield was 260 lbs. of marketable fruit and 54 lbs. pitted. The very high relative percentage of pit on these trees was attributed by the grower to the small crop, and the fruit being overgrown. The average yield per tree on the experimental plots of marketable fruit was 91 lbs., while here it was only 43 lbs., or less than half.

2. At Government Farm, Bathurst, New South Wales.

The Government Experiment Farm adjoins the city of Bathurst, which is 145 miles west of Sydney. The orchard has an area of 43 acres, of which 35 acres were planted in 1896. The trees in this portion are now about sixteen years old, and there were two rows of Cleopatras in this division which were available for my proposed manurial experiments. The manager of the farm, Mr. Peacock, had already begun to experiment with manures, so that it was necessary for my purpose to utilize

what had already been done, as far as possible, for season 1911–12. Of course, the manures used were determined by the kind already applied, and the quantities were brought up to a given standard, while the unmanured plots were used as checks. There were nine plots altogether, each containing six trees, and the plan is as follows:—

o o o o Plot I. o o	o o o o Plot IV. o o	o o o o Plot VII. o o
o o o o Plot II. o o	o o o o Plot V. o o	o o o o Plot VIII. o o
o o o o Plot III. o o	o o o o Plot VI. o o	o o o o Plot IX. o o

The manure was first applied on 18th August, 1911, and a second dressing was given on 14th October, 1911, in order that the total quantity used in 1911 would be the same for the succeeding years during which the Bitter Pit experiments were to be continued.

The soil in which these experiments are being conducted is a sandy loam, with a heavy clay subsoil at an average depth of about 10 inches, and resting on a granitic formation. It is fairly uniform throughout the experiment plots, so that the results are quite comparable. The following analyses will show the nature of the soil and the percentage present of the four essential ingredients of plant-food, viz., nitrogen, phosphoric acid, potash, and lime:—

ANALYSES OF SOILS FROM BATHURST EXPERIMENT ORCHARD.

Source of Sample.	Colour.	Reaction.	Water Capacity.	Capillary Power.	Clay.	Lime (CaO).	Potash (K_2O).	Phosphoric Acid (P_2O_5).	Nitrogen. (N).	Volatile.	Remarks.
					Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
1. Top portion of orchard, sample taken from among the fruit trees—											
(a) Surface to 6″ deep ..	Light ..	Acid ..	Very low, 24 %	Good, 7″ ..	..	·187	·118	·104	·063	..	Moisture, 1·48 %
(b) 6″ to 12″ deep ..	Whitish ..	Neutral ..	Very low, 21 %	Very good, 8″	..	·107	·109	·050	·035	..	Moisture, ·95 %
(c) 12″ to 18″ deep ..	,, ..	,, ..	Very low, 25 %	Very good, 8″	..	·104	·064	·064	·035	..	Moisture, 1·15 %
(d) 18″ to 24″ deep ..	Reddish ..	Faintly acid ..	Low, 30 % ..	Very good, 9″	..	·233	·223	·083	·014	..	Moisture, 5·71 %
2. Typical virgin soil taken from orchard gate	Light brown	Strongly acid ..	Good, 42 % ..	Good, 7″ ..	59·2	·249	·184	·094	·154	5·34	This soil is composed of granite detritus redistributed by water
(a) Surface to 6″ deep ..	Light brown	Strongly acid ..	42 %	Good ..	59·2	·249	·184	·094	·154	5·34	These are the analyses of the above soil at different depths
(b) 6″ to 12″ deep ..	Grey ..	Very faintly acid	26 %	,, ..	54·2	·184	·103	·012	·070	1·92	
(c) 12″ to 18″ deep ..	Dark grey ..	Neutral ..	42 %	Fair ..	79·1	·307	·371	·052	·070	5·95	
(d) 18″ to 36″ deep ..	Brownish ..	Weakly alkaline	53 %	Poor ..	85·6	·420	·425	·064	·084	6·09	

The orchard is situated at an elevation of about 2,300 feet, with a western exposure, and there is a good natural drainage.

I am indebted to Mr. Johnston for the following rainfall records. The average rainfall for eleven years, 1901–11 inclusive, is 20·74 inches, and for the past year it was 24·48 inches. The monthly averages for the same eleven years are the following :—

	Inches.
January	2·32
February	1·76
March	2·08
April	1·41
May	1·16
June	1·64
July	1·57
August	1·64
September	1·85
October	1·80
November	1·61
December	1·90
	20·74 inches.

According to the orchardist (Mr. Grant) Bitter Pit is not so bad this season as in the two preceding seasons, and it will be interesting to compare the rainfall for the critical months in each season, November, December, and January, as well as the highest shade temperature during the summer.

—	Rainfall.			Highest Shade Temperature—Summer.
	November.	December.	January.	
	Inches.	Inches.	Inches.	Degrees.
1909–10	1·21	2·13	7·14	92·5
1910–11	·51	2·54	3·81	
1911–12	3·74	3·91	1·50	

The rainfall was much more variable and intermittent during the two preceding seasons.

As regards cultivation and treatment of the soil, the cover crop, such as barley, is put in about March, and then ploughed in about June, when it is coming into ear. The land is ploughed again between the trees in September, and also in November. If the season favours a growth of weeds the cultivator is used, so that the plough and the cultivator are kept at work.

The trees are planted on the square system, which is convenient both for planting and working, at 25 feet apart, giving an average of 70 trees to the acre. The treatment with respect to cultivation and pruning was uniform throughout. The trees were all sprayed with Swift's arsenate of lead at the rate of 1 lb. to 25 gallons of water on 12th and 30th October respectively and a spray of resin and soda was applied for Woolly Aphis on 15th November.

The first sign of Bitter Pit in Cleopatra apples was observed on 22nd January, when they were about half-grown, although previous to that, about the beginning of January, the following early varieties of apples were found to be badly affected :—Devonshire Redstreak, Bentley Sweet, Keswick Codlin, Coulton, Lord Wolseley, and Williams' Favourite.

The Manager favours me with the following points of interest:—The crops of 1910 and 1911 were the worst for Pit experienced for many years, and, I believe, since this orchard commenced to bear. The conditions of those years were heavy rains in January and February. Owing to the ploughing under of the green manuring crops as late as August in both years, the conditions during the early growth of the apples may be considered as droughty. This would allow of a check in growth before Christmas, and favorable conditions afterwards.

In 1911, the green manure crop was ploughed under in June. Good heavy rains fell in November and December. Good rain, over 1 inch, fell on 6th January, 1912. For the remainder of the apple season, it was decidedly droughty. The past season (1911–12) was not regarded with us as being favorable for pit.

TABLE XV.—MANURIAL EXPERIMENTS WITH APPLE TREES (CLEOPATRA) FOR BITTER PIT AT BATHURST EXPERIMENT FARM—SEASON 1911–12.

Manuring per Acre—1911.	Tree No.	Results. Yield. Good Fruit.	Results. Yield. Pitted Fruit.	Total.	Per Cent. Pitted.
		lbs.	lbs.	lbs.	
Plot I.—Check—Absolutely unmanured	1	219	4½	223½	2·01
	2	228	5	233	2·14
	3	181	2	183	1·09
	4	244	5	249	2·01
	5	277	1¼	278¼	0·45
	6	190	1½	191½	0·78
	Totals for 6 Trees ..	1,339	19¼	1,358¼	..
	Averages for 6 Trees ..	223	3·208	..	1·42
Plot II.—1 cwt. Sulphate of Potash 3 cwt. Ordinary Superphosphate	1	133	¾	133¾	0·56
	2	297	8	305	2·62
	3	214	9	223	4·04
	4	234	¼	234¼	0·10
	5	265	¾	265¾	0·28
	6	194	¾	194¾	0·38
	Totals for 6 Trees ..	1,337	19½	1,356½	..
	Averages for 6 Trees ..	222·8	3·25	..	1·44
Plot III.—1 cwt. Sulphate of Ammonia 3 cwt. Ordinary Superphosphate	1	261	10	271	3·69
	2	284	16	300	5·33
	3	172	1	173	0·58
	4	281	5	286	1·75
	5	185	¾	185¾	0·40
	6	219	1¼	220¼	0·57
	Totals for 6 Trees ..	1,402	34	1,436	..
	Averages for 6 Trees ..	233·6	5·66	..	2·36

TABLE XV.—MANURIAL EXPERIMENTS WITH APPLE TREES (CLEOPATRA) FOR BITTER PIT AT BATHURST EXPERIMENT FARM—SEASON 1911–12—*continued.*

Manuring per Acre—1911.	Results. Tree No.	Yield. Good Fruit.	Yield. Pitted Fruit.	Total.	Per Cent. Pitted.
		lbs.	lbs.	lbs.	lbs.
Plot IV.—Check	1	273	12	285	4·21
	2	238	1	239	0·42
	3	137	8	145	5·51
	4	53	1	54	1·85
	5	29	1¼	30¼	4·93
	6	119	3	122	2·46
	Totals for 6 Trees ..	849	26¼	875¼	..
	Averages for 6 Trees ..	141·5	4·37	..	3·00
Plot V.—1 cwt. Sulphate of Potash 3 cwt. Ordinary Superphosphate	1	268	3	271	1·11
	2	203	9	212	4·24
	3	195	12	207	5·79
	4	171	4¼	175¼	2·42
	5	180	1¾	181¾	0·97
	6	251	1½	252½	0·59
	Totals for 6 Trees ..	1,268	31½	1,299½	..
	Averages for 6 Trees ..	211·3	5·25	..	2·42
Plot VI.—32½ lbs. Sulphate of Ammonia 1 cwt. Sulphate of Potash 11 cwt. 11 lbs. Slaked Lime	1	233	7	240	2·91
	2	293	9	302	2·98
	3	152	8	160	5·00
	4	317	1¼	318¼	0·39
	5	220	1½	221½	0·68
	6	237	1½	238½	0·63
	Totals for 6 Trees ..	1,452	28¼	1,480¼	..
	Averages for 6 Trees ..	242	4·70	..	1·91
Plot VII.—Check	1	279	1¼	280¼	0·45
	2	267	..	267	..
	3	286	1	287	0·35
	4	234	5	239	2·09
	5	227	¾	227¾	0·33
	6	250	..	250	..
	Totals for 6 Trees ..	1,543	8	1,551	..
	Averages for 6 Trees ..	257·1	1·3	..	0·52

TABLE XV.—MANURIAL EXPERIMENTS WITH APPLE TREES (CLEOPATRA) FOR BITTER PIT AT BATHURST EXPERIMENT FARM—SEASON 1911–12—*continued.*

Manuring per Acre—1911.	Tree No.	Results. Yield. Good Fruit.	Pitted Fruit.	Total.	Per Cent. Pitted.
		lbs.	lbs.	lbs.	
Plot VIII.—1 cwt. Sulphate of Ammonia, 1 cwt. Sulphate of Potash, 2¼ cwt. Bone Dust	1	294	1½	295½	0·51
	2	286	1¾	287¾	0·61
	3	149	..	149	..
	4	119	3	122	2·46
	5	310	1½	311½	0·48
	6	199	4	203	1·97
	Totals for 6 Trees ..	1,357	11¾	1,368¾	..
	Averages for 6 Trees ..	226·1	1·95	..	0·86
Plot IX.—1 cwt. Sulphate of Ammonia, 1 cwt. Sulphate of Potash, 3 cwt. Ordinary Superphosphate	1	208	4	212	1·89
	2	260	5	265	1·88
	3	272	14½	286½	5·06
	4	168	2	170	1·18
	5	215	6	221	2·71
	6	279	5	284	1·76
	Totals for 6 Trees ..	1,402	36½	1,438½	..
	Averages for 6 Trees ..	233·6	6·08	..	2·54

Summary of Manurial Experiments.

Plot No.	Average Yield. Good Fruit.	Pitted Fruit.	Average Per Cent. Pitted.
	lbs.	lbs.	
1	223	3·208	1·42
2	222·8	3·25	1·44
3	233·6	5·66	2·36
4	141·5	4·37	3·00
5	211·3	5·25	2·42
6	242	4·70	1·91
7	257·1	1·3	0·52
8	226·1	1·95	0·86
9	233·6	6·08	2·54

NOTE.—Superphosphate was applied with the seed of the green manure crop in 1909. In 1910 and 1911, no Superphosphate was applied for the green manure crop.

Although no general conclusions can be drawn at this stage of the experiment, it may be noted that the percentage of Bitter Pit in each plot is comparatively small, the highest being 3 per cent., and the lowest only about ½ per cent. It is also noteworthy that the plots with the highest and the lowest percentage were treated exactly alike as regards manuring, not only in 1911, but in the two preceding years.

3. At Government Experiment Orchard, Blackwood, South Australia.

The experiments are being conducted at the Government Experiment Orchard, situated about 12 miles from Adelaide, in the Mount Lofty Ranges, about 800 feet above sea-level, and 8 miles from the sea-coast.

Ever since the inception of the orchard in 1908, Mr. George Quinn, Horticultural Expert, has initiated a series of experiments with various stocks in order to test their influence upon the development of Bitter Pit in apples, and this is being followed up with manurial, pruning, tillage, and irrigation experiments, with the same object in view.

From the very nature of these experiments, a number of years are necessary to realize their full value, but they will afford practical object-lessons, not only to the present generation of fruit-growers, but their value will become enhanced the longer the period over which they are extended.

The soil of the orchard is a reddish loam, with a good clay sub-soil at a depth of from 9 to 12 inches, and previous to being planted it had grown hay for a number of years. The following chemical analysis will show the essential constituents of the soil:—

RESULTS OF ANALYSES FROM SOILS IN WHICH APPLE TREES ARE GROWING WHICH HAVE BORNE FRUIT THIS SEASON, 1912.

Brand.		Nature of Soil.	(P_2O_5) Phosphoric Acid.	Potash.	Lime.	Nitrogen.	Fine Earth.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Light Soil	A. 1	8-in. Surface Soil	0·028	0·076	0·220	0·076	87·5
	A. 2	10-in. Subsoil	0·006	0·067	0·161	0·015	68
Dark Soil	B. 1	8-in. Surface Soil	0·032	0·077	0·196	0·111	92·5
	B. 2	9-in. Subsoil	0·023	0·090	0·238	0·058	85

During the past three years the rainfall has been rather variable, ranging from 25.70 inches in 1911 to 41.36 inches in 1909. The record for each month is given from the time the stock test apple trees were planted in August, 1908.

RAINFALL AT GOVERNMENT EXPERIMENT ORCHARD, BLACKWOOD, SOUTH AUSTRALIA.

Month.	1908.	1909.	1910.	1911.	1912.
	Inches.	Inches.	Inches.	Inches.	Inches.
January	..	·96	·32	·23	·25
February	..	·72	Nil	2·94	·50
March	..	·86	5·51	·94	·67
April	..	4·55	·28	1·22	
May	..	5·94	5·91	2·63	
June	..	3·85	3·37	5·02	
July	2·02	6·97	5·56	3·45	
August	3·81	7·44	2·52	1·57	
September	3·82	2·72	3·97	4·49	
October	3·79	3·72	2·46	·70	
November	·52	3·12	1·59	·35	
December	·71	·51	2·37	2·16	
Total	14·70 For Six Months	41·36 For Year	33·86 For Year	25·70 For Year	1·42 For ¼ Year

The trees are planted on the hexagonal system, at a distance of 20 feet apart.

The cultivation of the orchard was carefully attended to. It was ploughed twice during the winter, and scarified several times and harrowed during the summer. The trees were also dug and hoed around.

The Cleopatra trees used in these experiments on Northern Spy stocks were planted out in August, 1908, when one year old, and the first manurial dressing was applied in September, 1909. There were three trees in each plot, and in every instance there was a guard or barrier row of trees between each plot, without any manure.

The manure has now been applied for three years in succession, viz., 1909, 1910, 1911, and the yield of fruit is here recorded for 1912, distinguishing between pitted and clean :—

TABLE XVI.—RESULTS OF MANURIAL EXPERIMENTS WITH CLEOPATRA APPLES, SEASON 1911–12.

Test No.	Manure used per Tree each year.	Dates Gathered.	Date of last Examination.	Results *re* Bitter Pit.
1	No manure	26.2.1912 9.3.1912	16.5.1912	56 clean, 5 pitted, 3 fell immature
2	1 lb. superphosphate ..	26.2.1912 9.3.1912	,,	58 apples clean, 4 fell immature
3	1 lb. superphosphate .. 2 lbs. lime	,,	,,	3 apples clean
4	1 lb. superphosphate .. $\frac{1}{4}$ lb. sulphate potash ..	26.2.1912 9.3.1912	,,	26 apples clean, 1 fell immature
5	1 lb. superphosphate .. $\frac{1}{4}$ lb. sulphate potash .. $\frac{1}{4}$ lb. sulphate ammonia	26.2.1912 9.3.1912	,,	13 apples clean, 1 pitted, 1 fell immature
6	No manure	26.2.1912	,,	1 apple clean
7	1 lb. superphosphate .. $\frac{1}{4}$ lb. sulphate potash .. $\frac{1}{4}$ lb. sulphate ammonia .. 2 lbs. lime	26.2.1912 9.3.1912	,,	10 apples clean, 1 fell immature
8	2 lbs. lime	9.3.1912	,,	5 apples clean
9	$\frac{1}{4}$ lb. sulphate ammonia .. $\frac{1}{4}$ lb. sulphate potash ..	26.2.1912 9.3.1912	,,	14 apples clean, 3 fell immature
10	1 lb. superphosphate .. $\frac{1}{4}$ lb. sulphate ammonia ..	26.2.1912 9.3.1912	,,	20 apples clean, 1 apple pitted
11	56 lbs. stable manure ..	26.2.1912 9.3.1912	,,	20 apples clean, 1 apple pitted, 4 fell immature
12	No Manure	26.2.1912 9.3.1912	,,	27 apples clean, 1 apple pitted, 8 fell immature
13	$\frac{1}{4}$ lb. sulphate of iron ..	..	..	Planted 1909—not fruited yet

MANURIAL EXPERIMENTS.

4. AT MR. ANDREWS' ORCHARD, CRAIGBURN, TAMAR VALLEY, TASMANIA.

This orchard, lying in a recess of granite hills, has a grey loamy soil, overlying a good friable clay subsoil on top of gravel. The soil is of a porous nature.

There were large blocks of Cleopatra apple trees very suitable for experiment, being eight years old, as they were planted six years, and two years old at time of planting. They are all at a good bearing age, having borne profitably for three years, and carried fruit for four. The trees are planted on the triangular system, which is well adapted for a permanent orchard, and are 20 feet apart, so that there are 108 trees to the acre.

After the fruit is picked there is no cultivation until the spring, in order to allow the weeds to grow freely for ploughing in. As soon as it is ploughed, it is worked up with the disc cultivator, and this is continued until the end of the year, about half-a-dozen discings being given. The Spring Tooth Cultivator is generally used after that, and the ordinary harrows after a shower. If the weather is particularly dry in January, the harrows may be used to keep the moisture in. The average rainfall is about 35 inches. Since there is no codlin moth in this orchard, there is no spraying with arsenate of lead.

Detailed results are not available for the past season, which showed much less Bitter Pit than usual. The apples, when gathered from the whole experimental area, including the guard trees, gave an average of exactly 5 per cent. When the manures already applied have had time to act, no doubt there will be a difference in the plots, and the results will be carefully recorded.

There were nine manurial plots, consisting of eight trees each, and with guard trees between. The kinds and quantities of manure applied were as follows :—

Manurial Experiments.

Plots.	Kinds and Quantities of Manure per Acre.—Eight Trees in each Plot.		Per Tree.	
1		Check		
2	1	1 cwt. sulphate of ammonia	¾ lb.	
		3 cwt. ordinary superphosphate	2½ ,,	
		1 cwt. sulphate of potash	¾ ,,	4 lbs., Plot 1
3		Check		
4	2	1 cwt. sulphate of ammonia	¾ lb.	
		1 cwt. bonedust	¾ ..	
		2 cwt. ordinary superphosphate	1½ ..	
		1 cwt. sulphate of potash	¾ ..	3¾ lbs., Plot 2
5		Check		
6	3	1 cwt. sulphate of ammonia	¾ lb.	
		3 cwt. ordinary superphosphate	2½ ,,	
		4 cwt. kainit	3¼ ,,	6½ lbs., Plot 3
7		Check		
8	4	3 cwt. ordinary superphosphate	2½ lb.	
		1 cwt. sulphate of potash	¾ ,,	3¼ lbs., Plot 4
		Green manuring, with leguminous crop every alternate year		
13		Check		
14	5	Green manuring alone every alternate year		
15		Check		
16	6	Green manuring every alternate year, plus 5 cwt. slacked lime		
17		Check		
18	7	3 cwt. ordinary superphosphate	2½ lb.	
		1 cwt. sulphate of potash	¾ ,,	3¼ lbs., Plot 7
19		Check		
20	8	1 cwt. sulphate of ammonia	¾ lb.	
		3 cwt. ordinary superphosphate	2½ ,,	
21		Check		3¼ lbs., Plot 8
22	9	6 lbs. bonedust (per tree)	Plot 9	
		1 lb. sulphate of potash (per tree)		
		½ lb. sulphate of iron (per tree)		

B.—PRUNING EXPERIMENTS.

While Bitter Pit may occur on both pruned and unpruned trees, it is nevertheless desirable to test the relative effects of severe, light, and leader pruning, as well as no pruning at all, on this disease. In the experiments hitherto carried out in Victoria, the Principal of the Burnley School of Horticulture has kindly pruned the trees, so that in the different experiment orchards there is a regular gradation observed between those trees of the same variety severely pruned and those left without pruning.

In South Australia, Mr. Quinn is testing the influence on this disease of winter and summer pruning, with and without the thinning of fruit, as compared with trees never pruned and fruit not thinned.

Root pruning will also be attended to, although in our variable climate, in cases where the orchard is dependent upon the natural rainfall, there is a danger of such trees suffering, at a critical period of their growth, from a diminished water supply.

The tree chosen for this experiment is of the Prince Bismarck variety, eleven years old, and very liable to Pit. It was rooted out on 19th June to show the nature and spread of the root-system (Fig. 133), and replaced after cutting back the roots to within 3 feet of the trunk. Fresh sandy soil was supplied, with the addition of 4 lb. of blood manure and bonedust around where the roots were pruned, and about 1 cwt. of well-rotted stable manure mixed with the soil.

This tree was dug out by the roots to show the relation between the shoot-system and the root-system. The soil is loamy for 15 inches, with a stiff clay subsoil. The tree was about 10 feet high, with a spread of 5½ feet each way. There was no tap-root, and the longest roots extended for 12 to 14 feet, and passed through the stiff clay.

If a scientific system of pruning could be adopted, combined with judicious thinning, so as to prevent the regular recurrence of heavy and light yields, and give a regular, even, steady growth of fruit from season to season, it would tend in the direction of lessening the Pit.

5. At Burnley Horticultural Gardens.

These gardens are only about 3 miles from Melbourne, and are very conveniently situated for experimental work. They are 50 feet above sea-level, and about 3½ miles distant from the sea. They owe their origin to the Royal Horticultural Society of Victoria, which was established in 1849, and one permanent result of the efforts of its members was the experimental gardens, now associated with a School of Horticulture, under the Department of Agriculture.

They contain a large and valuable collection of fruit trees, and of apples alone there are 672 varieties under observation. Such a collection, accurately named, and with the history of most of the trees known, is of inestimable value in connexion with the investigation of Bitter Pit, more particularly as this disease is more or less prevalent every year. I am also fortunate in that the Principal, Mr. E. E. Pescott, has taken a lively interest in the progress of this investigation, has cordially co-operated with me in every line of experiment, and has carried out the work in connexion with pruning and stocks as far as the resources of the gardens would allow.

Manurial experiments have not been carried out here, since from the very object of the gardens being to have a standard collection of fruit trees, there is no single variety largely represented by numbers. The majority of the apple trees are on the dwarf system, because it was found necessary to economize space, in order to make provision for the existing collection, as well as the addition of new varieties. The Paradise stock is considered the most suitable for dwarfing purposes, but, owing to its liability to Woolly Blight, a system of double grafting has been tried. In season 1888–9 it

was reported that—" We have now 600 kinds of apples growing upon the dwarf system, and several kinds of stocks have been tested in various ways, viz. :—(1) Paradise root stock only; (2) Paradise root with Winter Majetin as intermediate; (3) Paradise root with Northern Spy as intermediate; (4) Northern Spy root with Paradise as intermediate; (5) a dwarf blight-proof stock obtained from the Siberian Crab was used. The most satisfactory results were obtained from the fourth test, viz., Northern Spy root with Paradise intermediate, the Paradise intermediate being grafted on to the Northern Spy, 4 or 5 inches above the ground, and the variety 4 inches above that again, leaving 4 inches Paradise intermediate."

The dwarf trees are all planted 6 feet by 6 feet, and the cultivation consists in hand digging the soil and hoeing between the rows and around the trees all through the season. The manure applied in 1910 was 1 ton of tobacco stems and 10 tons garden litter and stable manure per acre. In 1911, 20 tons stable manure and 5 cwt. lime were applied per acre.

The entire orchard is underdrained with tile drains. The system of pruning has been light for the past four years, but previously it was rather heavy.

In the portion of the orchard where the dwarf trees are, it is alluvial soil and silt below, and in the other portion it is a clay loam.

The chemical and mechanical analyses of the soil are as follows, No. 1 being the clay loam and No. 2 the alluvial soil.

Report on Analysis of Soils from Burnley Horticultural Gardens.

—	No. 1. Top Soil—Apple. Clay from 0–12".	No. 1A. Sub-soil—Apple. Clay, 12" to 21".	No. 2. Alluvial Soil, 0–17".	No. 2A. Silt Sub-soil, 17"–30".
	%	%	%	%
Nitrogen	·117	·151	·098	·066
Phosphoric acid	·051	·042	·026	·006
Potash	·105	·081	·266	·009
Lime	·200	·251	·110	·032
Magnesia	·242	·138	·650	·065
Chlorine	·004	·004	·008	·004
Reaction	Neutral	Neutral	Neutral	Slightly acid

Mechanical Analysis.

—	No. 1.	No. 1A.	No. 2.	No. 2A.
Very coarse sand (2–1)	0·00	0·00	0·45	0·35
Coarse sand (1–·5)	4·85	0·85	6·50	4·45
Medium sand (·5–·25)	6·05	1·45	8·50	5·50
Fine sand (·25–·1)	21·20	12·90	29·85	29·90
Very fine sand (·1–·05)	38·90	25·85	34·80	41·75
Silt (·05–·01)	3·45	0·70	2·90	4·90
Fine silt (·01–·005)	3·25	2·45	2·80	2·50
Clay (·005)	18·14	47·11	11·43	10·04
Moisture	0·96	3·23	0·27	0·06
Loss on ignition	3·20	5·46	2·50	0·55

The rainfall is given at Melbourne for the spring, summer, autumn, and winter months for the past three seasons, and for each month of the past year and the present up to and including May :—

	1909–10. Inches.	1910–11. Inches.	1911–12. Inches.
Spring (Sept., Oct., Nov.) ..	.. 4·07	.. 9·33	.. 6·98
Summer (Dec., Jan., Feb.) ..	.. 5·34	.. 4·13	.. 10·28
Autumn (March, April, May)	.. 6·25	.. 5·59	.. 11·97
Winter (June, July, Aug.) ..	.. 8·06	.. 4·69	.. 7·35

		1911. Inches.	1912. Inches.
	January	.. 1·29	.. 0·47
	February	.. 5·35	.. 0·94
Autumn	March ..	.. 7·50	.. 0·74
	April ..	.. 1·12	.. 2·33
	May ..	.. 3·35	.. 1·35
Winter	June ..	.. 3·72	
	July ..	.. 2·26	
	August ..	.. 1·37	
Spring	September	.. 3·06	
	October	.. 2·54	
	November	.. 1·38	
	December	.. 3·67	
	Total ..	.. 36·61	

A row of London Pippins or Five Crowns, about ten years old, on Northern Spy stocks was used for the pruning experiments, and the results are given in the following table :—

Table XVII.—Results of different Methods of Pruning on London Pippin or Five Crown Apple Trees.

No. of Tree.	Pruning.	Yield.	No. of Apples Crinkled.	Remarks.
		lbs.		
1	Severe ..	29	..	Generally small apples, and tree affected with tree-killing fungus
2	,, ..	93	8 (1 with Bitter Pit)	
3	,, ..	86	..	
5	Light ..	127	6	
8	,, ..	91	2	
9	,, ..	98	10	
10	Leader ..	100	2	
12	,, ..	195	21	Altogether a larger and more vigorous tree than the others
13	None ..	137	4	
14	,, ..	152	1	

An occasional apple was affected with Bitter Pit, and sometimes it was combined with crinkle ; but there was practically only the one disease on all the trees. Although No. 1 tree had the lightest crop of all, the apples were very small. The amount of crinkle altogether is so very

small that no conclusions are drawn for this first season as to the effect of different methods of pruning upon it; but since this variety is particularly subject to crinkle, the pruning experiments in succeeding years will show how far confluent Bitter Pit is influenced by the methods of pruning adopted.

6. At Albert Smith's Orchard, Deepdene, near Melbourne.

On visiting Mr. Smith's orchard at Deepdene, about 7 miles from Melbourne, in August, 1911, I found him cutting back all his Cleopatra trees on account of Bitter Pit, in order to re-graft them. He informed me that the fruit was so badly pitted that it was simply useless as a commercial crop. There were four rows altogether, and he had cut them all back, with the exception of three in each row, when I stayed his hand, as I saw they would be very useful for experimental purposes. On explaining the matter to him, he kindly allowed me the use of the trees, although it interfered with his plans, and I have to express my indebtedness to Mr. Smith for his public spirit in thus furthering the investigation of Bitter Pit.

The immediate object of the experiment was to leave the trees unsprayed, as they were so very susceptible to the disease, and thus test the question which had been raised as to spraying, particularly with arsenical compounds, being the cause of Bitter Pit. As the trees were in a corner of the orchard they were ideally situated for this purpose, and, in order to utilize the plot as much as possible, I also tested the effect of different methods of pruning; leaving, however, the plot in the very corner unpruned, so as not to interfere in any way with the results as regards Bitter Pit from non-spraying.

The plan of the block of twelve trees is as follows:—

(Paddock Fence.)

	o	o	o	o	
(General Orchard.)	o	o	o	o	(*Hakea Hedge.*)
	o	o	o	o	
	Severe pruning.	Light pruning.	Leader pruning.	No pruning.	

The results of the pruning experiments only will be given here, the effects of non-spraying having been previously referred to. The soil of the orchard is a sandy loam, with a clay bottom at a depth of about 18 inches. The trees are nine years old, and they were planted at a distance of 20 feet either way, the stock being the Northern Spy. The pruning was fairly severe in 1910, and they were also summer pruned. The ground was ploughed once in October, and the drainage is fairly good.

The crop in 1911 was fully 2 bushels per tree of well-grown apples, but, as the grower expressed it, "They were all left on the ground for Pit." Although the trees were unsprayed, there was a good setting of fruit on the whole when I visited the orchard on 21st October. The trees were pruned on 22nd August by Mr. E. E. Pescott, so as to be quite comparable with those pruned at Burnley Horticultural Gardens, and exactly on the same plan of severe, light, and leader pruning, as already explained, leaving one row unpruned as a check.

Frequent visits were paid to the orchard in the interval, and great care was taken, not only that the trees were left absolutely unsprayed, but when the general orchard was being sprayed that none of the spray was carried in that direction by the wind.

The fruit was picked on 16th March, 1912, when it was almost ripe, and as might be expected from the absence of spraying, not only was every apple badly affected with Black Spot or Scab so

as to be entirely unmarketable, but the trees themselves were badly affected with Woolly Aphis. The results are given in the following table :—

TABLE XVIII.—RESULTS OF DIFFERENT METHODS OF PRUNING ON CLEOPATRA APPLE TREES.

Pruning.	No. of Apples.	Weight of Fruit.	Bitter Pit.	Remarks.
		lbs.		
Severe ..	31	5¾	Four apples	
Light ..	41	8	Five apples, all full grown	The largest proportion of big apples in any of the plots
Leader ..	33	6	Two apples, big, the largest in the lot	
None ..	28	3½	One apple, moderately sized	

These results have no special value from the point of view of pruning, since any effect produced by it was counteracted by the general development of Black Spot, owing to the absence of spraying, but they are given for comparison with future results when the trees will be similarly pruned and treated in every other respect as in the general orchard, including spraying.

I have also to acknowledge that the smallness of the plots will hardly give a fair test of the effects of the different methods of pruning on Bitter Pit, but since it was necessary for the purpose in view to select a very susceptible variety, and since the Cleopatra is such a noted "pitter," and has been so generally discarded, it was exceedingly difficult to get large blocks of this variety for experimental purposes.

This experiment, however, shows incidentally the value of spraying in the production of a crop free from Black Spot, and is so instructive that a photograph is given (Fig. 122) of the yield of the twelve trees when this necessary operation was neglected.

7. AT GOVERNMENT FARM, BATHURST, NEW SOUTH WALES.

Experiments with hard, medium, and no pruning at all were carried out with Cleopatras, and, as there were from ten to twelve trees in each plot, there is sufficient variety to secure average results. The following are the results :—

TABLE XIX.—HARD PRUNING—TWELVE CLEOPATRA TREES IN TWO ROWS.

Tree No.	Yield of— Good Fruit.	Yield of— Pitted Fruit.	Total.	Per cent. Pitted.
	lbs.	lbs.	lbs.	
Row 1 { 1	158	4	162	2·47
2	199	3	202	1·49
3	216	2	218	0·92
4	225	5½	230½	2·38
5	162	4¼	166¼	2·56
6	192	2	194	1·03
Row 2 { 1	168	2	170	1·18
2	101	3	104	2·88
3	117	4	121	3·31
4	198	3	201	1·49
5	219	5	224	2·23
6	168	6	174	3·45
Totals for 12 trees	2,123	43¾	2,166¾	..
Averages for 12 trees	176·9	3·64	..	2·02

TABLE XX.—MEDIUM PRUNING—TEN CLEOPATRA TREES IN TWO ROWS.

Tree No.		Yield of— Good Fruit.	Yield of— Pitted Fruit.	Total.	Per cent. Pitted.
		lbs.	lbs.	lbs.	
Row 1	1	115	2	117	1·71
	2	198	6	204	2·94
	3	208	13	221	5·88
	4	192	9	201	4·48
	5	193	15	208	7·21
Row 2	1	92	½	92½	0·54
	2	210	9	219	4·10
	3	146	3	149	2·01
	4	231	13	244	5·33
	5	98	9	107	8·41
Totals for 10 trees		1,683	79½	1,762½	..
Averages for 10 trees		168·3	7·95	..	4·51

TABLE XXI.—NO PRUNING—TWELVE CLEOPATRA TREES IN TWO ROWS.

Tree No.		Yield of— Good Fruit.	Yield of— Pitted Fruit.	Total.	Per cent. Pitted.
		lbs.	lbs.	lbs.	
Row 1	1	216	4	220	1·82
	2	192	5	197	2·54
	3	211	1	212	0·47
	4	192	3	195	1·54
	5	219	2	221	0·90
	6	236	4	240	1·67
Row 2	1	219	..	219	..
	2	258	4	262	1·53
	3	198	2	200	1·00
	4	216	½	216½	0·23
	5	123	3	126	2·38
	6	194	½	194½	0·26
Totals for 12 trees		2,474	29	2,503	..
Averages for 12 trees		206·1	2·4	..	1·16

TABLE XXII.—SUMMARY OF PRUNING EXPERIMENTS.

—	Average Yield. Good Fruit.	Average Yield. Pitted Fruit.	Average per cent. of Pitted Fruit.
	lbs.	lbs.	
Hard pruning	176·9	3·64	2·02
Medium pruning	168·3	7·9	4·51
No pruning	206·1	2·4	1·16
Medium pruning (single tree pit liable)	139	30·	17·75
Unpruned for 10 years (single tree)	396	2·	0·50

The results of a single season show that the hard-pruned Cleopatra trees have less than half as much Pit as the medium pruned, while those not pruned at all have considerably less than any of the others.

There is one special Cleopatra apple tree (Fig. 123) which is now sixteen years old, and was loaded with fruit. It was pruned for the first six years, and has been left unpruned for the past ten years. The quantity of fruit is much higher than the average, but it is small, the average size being only about 2 inches. It is interesting to note, however, that it shows an exceedingly small amount of Pit, only ½ per cent. It will be observed from the photograph that the branches are all pendent, and it bears out the contention of those orchardists who maintain that, when the bearing branches are more or less bent, and pruning is not directed towards rigid uprightness, the liability to pit is very much lessened.

8. At Government Experiment Orchard, Blackwood, South Australia.

The trees in these plots were planted in August, 1910, and pruned the same year rather severely. The varieties chosen are Cleopatra, Munroe's Favourite or Dunn's Seedling, Jonathan, Scarlet Nonpareil, and Rome Beauty. There is no fruit as yet, but the nature of the experiments may be given.

1. Pruned every year—Fruit not thinned.
2. Pruned first three years, then not pruned—Fruit thinned.
3. Never pruned—Fruit not thinned.
4. Pruned three winters, then every second winter.
5. Pruned every winter, and summer pruned.

C.—EXPERIMENTS WITH STOCKS.

In order to determine the influence of the stock on the development of Bitter Pit in a satisfactory manner, a longer period of time would be required than is available, but I have adopted a method for getting results more quickly, and which will at least indicate if the stock is an important factor.

Fortunately, a series of experiments are being conducted in South Australia by Mr. Quinn, which will show the effect of the stock on Bitter Pit during a number of years, and in a thorough manner.

Not only are experiments being carried out with apple-tree stocks, but also with pear trees. Some varieties of pear trees are affected with Bitter Pit, and in the same orchard there are individual trees which have always been free. Grafts from the affected trees will be worked on the clean trees, and *vice versâ*, to see the result.

As showing the influence of the stock on the scion, I have selected the Gravenstein apple tree. It is a strong grower, forming a large spreading head, but it has the habit of producing a ribbed trunk and twisted and deformed branches. So much is this considered to be a hereditary quality of this variety, that Mr. Lang, in describing it in the *Agricultural Journal of Victoria* for January, 1905, writes:—"A peculiarity of this tree is the bossed and uneven appearance of the trunk and main branches, many of the branches having a twisted and gnarled appearance." As long as this variety was grafted on to Northern Spy stock, it developed the deformity, as shown in Figs. 126, 127, 128, but, whenever it was grafted on the Spy roots, there was no appearance of it (Fig. 129). The trees photographed were about thirteen years old. There were about 80 of them growing in this orchard, and wherever they were root-grafted they were perfectly normal. The soil is alluvial, with clay about 3 feet deep. The stocks used were taken from healthy well-grown Gravenstein trees, and in the one row (Fig. 126) with the same soil, you can easily pick out those not root-grafted from their twisted and contorted branches. The Gravensteins one usually meets with are deformed, and Mr. Peacock, of the Government Farm, New South Wales, writes—"We have no Gravensteins on seedling stocks or Spy roots, but the tree on the Spy stock is badly twisted."

9. At Burnley Horticultural Gardens.

(A) *Bark-grafting of Liable Varieties on Orchard Trees.*

Six different varieties of apple tree were selected, known to be blight-proof, and four limbs were cut away from each. On these were bark-grafted scions of four varieties, which were among the worst for Bitter Pit. The stocks were Northern Spy, Winter Majetin, French Paradise, Coral Crab, Duchess of Oldenburg, and Lord Wolseley. Northern Spy and Lord Wolseley are very liable varieties, and they will be useful for comparison with the others. The scions were Cleopatra, Annie Elizabeth, Cox's Orange Pippin, and Bismarck. They were grafted on 5th September, 1911, and two were put on each branch (Fig. 125).

All the varieties have taken with the exception of Cox's Orange Pippin, which failed on Winter Majetin. On the same stock Cleopatra did not produce fruit-buds, although they set in every other instance. It was noticeable that Cleopatra made the best growth in every instance when an examination was made on 19th June.

In all probability, some fruit will be produced next season, and its liability to or freedom from Bitter Pit will be closely watched.

(B) *Testing the Influence of Different Stocks.*

A number of different stocks were used, on which were budded or grafted mostly susceptible varieties, and planted in the bird-proof inclosure on 23rd August, 1911 (Fig. 124*a*).

They were all pruned on 13th September, as shown in Fig. 124*b*. They were examined on 19th June, 1912, and generally it was found that they had all made good growth, and a number of them will carry fruit next season. On Magg's Seedling and Yarra Bank stock the growth is not so vigorous as in the others.

Prince Bismarck budded on Northern Spy bore four clusters of apples on the terminal buds (Fig. 132). As a result of the hot spell in January, followed by rain, the terminal buds flowered and produced what is known as a second growth.

The varieties budded or grafted on the various stocks are as follows:—

(C) *Stocks used in the General Orchard.*

In the list of varieties subject to Bitter Pit at Burnley Gardens (Appendix V.), it will be seen what a variety of stocks are used, and their effect upon the prevalence or otherwise of Pit can be noted in succeeding years. The greater number of the varieties are worked on the French Paradise on Northern Spy roots, but the following are also used:—Annie Elizabeth, Cox's Orange Pippin. Ecklinville Seedling, Esopus Spitzenberg, Gravenstein, Kentish Fillbasket (Colonial), Lord Wolseley, Munroe's Favourite, Perfection (Shepherd's), and Prince Bismarck. Different varieties on the same stock, and the same variety on different stocks, will be compared:—

(*a*) On Northern Spy Stocks Direct—

1. Cox's Orange Pippin budded on Northern Spy	2 years old when planted.
2. Blenheim Orange grafted on Northern Spy ..	1 year old when planted.
3. Ribston Pippin grafted on Northern Spy ..	1 ,, ,, ,,
4. King David budded on Northern Spy ..	1 ,, ,, ,,
5. Prince Bismarck budded on Northern Spy ..	1 ,, ,, ,,
6. Cleopatra budded on Northern Spy ..	1 ,, ,, ,,
7. Annie Elizabeth budded on Northern Spy ..	1 ,, ,, ,,

(*b*) On Yarra Bank Stocks Direct—

8. Cleopatra budded on Yarra Bank	2 trees, and 2 years old when planted
9. Annie Elizabeth budded on Yarra Bank ..	2 ,, 2 ,, ,, ,,

(*c*) On Duchess of Oldenburg Stock Direct—
10. Cleopatra budded on Duchess of Oldenburg .. 2 years old when planted.

(*d*) On Magg's Seedling Stock Direct—
11. Annie Elizabeth budded on Magg's Seedling .. 2 years old when planted.

(*e*) On Northern Spy Roots with Paradise Intermediate—
12. Prince Bismarck on Paradise on Spy .. .. 2 years old when planted.

10. Experiments with Stocks at Blackwood, South Australia.

Quite an elaborate series of experiments, testing the influence of different stocks on the development of the disease, are being carried out by Mr. Quinn. The trees were worked in an Adelaide Nursery in September, 1907, and planted in the Experiment Orchard in August, 1908.

Table XXIII.—Northern Spy Roots with Intermediate Stocks.—Testing the Influence of Different Stocks.

	Test No.	Description of Trees and Stocks Used.	Dates Gathered.	Date of Last Examination.	Results *re* Bitter Pit.
B1—B2.—Soil Samples.	1	Baldwin on Dunn's Seedling on Spy	9.3.1912 4.4.1912	16.5.1912	3 apples clean, 11 pitted, 3 fell immature.
	2	Baldwin on Rokewood on Spy	..	..	Not fruited yet.
	3	Baldwin on Rokewood ..	..	..	Not fruited yet.
	4	Cleopatra on Dunn's Seedling on Spy	24.2.1912 16.3.1912 26.3.1912 4.4.1912	16.5.1912	1911—1 apple pitted. 1912—16 apples clean, 5 pitted.
	5	Cleopatra on Rokewood on Spy	25.3.1912 4.4.1912	,,	11 apples clean, 2 fell immature.
	6	Cleopatra on Spy	21.3.1912	..	8 apples clean.
	7	Cleopatra (Q) on Dunn's Seedling on Spy	,,	..	1 apple clean, 1 fell immature.
	8	Cleopatra (Q) on Rokewood on Spy	26.3.1912 4.4.1912	,,	9 apples clean, 6 pitted, 1 fell immature.
	9	Cleopatra (Q) on Spy ..	9.3.1912 14.3.1912 4.4.1912	,,	8 apples clean.
A1—A2.—Soils.	10	Esopus Spitzenberg on Dunn's Seedling on Spy	14.3.1912 4.4.1912	..	2 apples clean.
	11	Esopus Spitzenberg on Rokewood on Spy	11.3.1912 4.4.1912	,,	1 apple clean, 2 pitted.
	12	Esopus Spitzenberg on Spy ..	..	..	Not fruited yet.
	13	Jonathan on Dunn's Seedling on Spy	2.3.1912	16.5.1912	17 apples clean, 9 pitted.
	14	Jonathan on Rokewood on Spy	..	..	1911—2 apples clean. 1912—48 apples clean, 2 crinkled, 1 crinkled and pitted, 2 pitted, 16 fell immature.
	15	Jonathan on Spy	,,	,,	6 apples clean, 7 pitted.
	16	Shockley on Dunn's Seedling on Spy	9.3.1912 21.3.1912 12.4.1912	,,	41 apples clean, 2 crinkled, and 3 pitted.
	17	Shockley on Rokewood on Spy	9.3.1912 12.4.1912	,,	1911—1 apple clean. 1912—56 apples clean, 2 pitted
	18	Shockley on Spy	1.4.1912 4.4.1912	,,	7 apples clean.

D.—CULTIVATION TESTS.

The effects of various modes of cultivation are being tested with apples. Different blocks of similar land are reserved at the Government Experiment Orchard, South Australia, for this purpose. In No. 1 block the land is sub-soiled, ploughed once, and summer tilled; in No. 2, sub-soiled, ploughed twice, and summer tilled; and in No. 3 not sub-soiled, ploughed twice, and summer tilled. The temperature of the soil will vary under different methods of treatment, and the development of Bitter Pit may, in this way, be influenced.

E.—IRRIGATION EXPERIMENTS.

11. At Mr. Jas. Cowan's Orchard, Bacchus Marsh, Victoria.

The soil in this orchard is alluvial, composed of the washings from volcanic and slaty country. It is 26 feet in depth, and naturally drained.

A row of Sturmer Pippins, consisting of fourteen trees about twelve years old, were kindly placed at my disposal for experiment to test the effect of watering on the development of Bitter Pit. The first watering was given to all the trees early in December, 1911, and a second early in February, with the exception of three trees. The fruit was picked on 24th April, and there was no noticeable difference in the yield between those watered only once and those watered twice. There were about 140 bushel cases, or 5,600 lbs. of fruit on all the trees, but there was a distinct difference in the amount of Bitter Pit. In the trees watered twice, there was 3 per cent. of Bitter Pit, while in those watered once there was 8 per cent.

The rainfall was as follows in 1911 and 1912:—

	1911. Inches.		1912. Inches.
January	1·01	January	0·21
February	3·63	February	2·11
March	7·63	March	1·02
April	0·58	April	1·01
May	1·92	May	0·47
June	2·37		
July	1·03		
August	0·73		
September	4·63		
October	1·72		
November	0·34		
December	3·64		
Total	29·23		

Next season half of the trees in the row will be fully watered, and the other half sparingly watered, and a comparison made between the amount of Bitter Pit in each case.

F.—COLD STORAGE EXPERIMENTS.

It is hardly necessary to dwell upon the advantages of cold storage as far as the carriage of fruit is concerned, but it is with reference to the development of Bitter Pit in transit that these experiments have been undertaken, in conjunction with Mr. W. C. French, Engineer-in-Charge. As far back as 1873 the Royal Horticultural Society of Victoria took a practical interest in the forwarding of fruit to Europe, and of the fruits which had been carefully packed and forwarded to

the Vienna Exhibition by the Society, the report was as follows, under date 6th June :—" The jury came this morning, and was quite struck with the apples, pronounced them magnificent, and that there was nothing to come up to them in the Exhibition." This was followed in 1881 by trial samples being sent to India, Ceylon, and London, and of the latter it was reported—" The experiment has proved beyond a doubt that Victorian fruit can be safely shipped to London, if due care be taken on its transit."

Now that cold storage is provided on board the ocean-going steamers, and cool stores erected in many of the apple-growing districts, the fruit export trade has been placed on a sound basis. But to insure that there is no development of Bitter Pit in transit, in those varieties liable to develop it in store, it is necessary to take certain precautions. This was strikingly shown in connexion with a case of apples of the Lord Suffield variety exhibited at the Fruit and Floral Carnival, held in the Exhibition Building, Melbourne, towards the end of March. A miniature cool store was erected there by Mr. French, and, among other samples placed in it, was the one above referred to. The fruit came from the Doncaster district, and was picked for exhibition purposes, showing no external sign of Bitter Pit. The case was kept in cool storage at a temperature of 31½–32° Fahr. for a fortnight and then forwarded direct to the exhibition, being perfectly clean. But on the last day of the exhibition, and after being in the miniature cool store for a week, it was observed that the great majority of the apples were badly " pitted."

I secured the case, and out of the 88 apples contained in it 72 were pitted, some badly, or a proportion of nearly 82 per cent. The reason for this was easily explained. Under the conditions of the exhibit, the temperature could not be regularly controlled, and it varied from 32–40° Fahr., while the air circulating in the chamber was rather moist. The fluctuating temperature, combined with the damp atmosphere, enabled the Bitter Pit to develop. The sixteen sound apples were kept on a shelf in the laboratory, and in two and a half months six of them had developed the disease.

The conditions necessary for successful carriage are clearly given by Mr. French in his Annual Report for 1910—" I would advocate, with every confidence, the dry air circulation system, by means of fans and batteries of ammonia expansion coils. Under this system ventilation and humidity are under perfect control. Humidity can be controlled by means of calcium chloride in connexion with the battery. A uniform low temperature is essential to the successful storage of fruit in transit. Another most important point to be noted is that the carbonic acid gas given off from the fruit must be drawn away by exhaust fans. Ventilating the packages so as to allow of a perfect circulation of air through each package is also a matter deserving particular attention."

Esopus Spitzenberg Apples.

This variety of apple was chosen for experiment, because it usually develops pit in store, after being removed from the tree. The fruit was grown at Box Hill by Mr. Hatfield, and picked on 10th April, when the fruit was on the turn—full grown and just beginning to ripen. Nine cases apparently clean were reserved. Three were sent to the Doncaster Cool Stores on 12th April, and kept at a uniform temperature of 30–32° Fahr. At the same time another case was sent for pre-cooling, being reduced to a temperature of 34–35° Fahr., and the apples were carefully wrapped in paper. This, along with another case similarly wrapped, but without pre-cooling, was forwarded to London, per R.M.S. *Osterley*, which sailed on 18th April. The pre-cooled fruit was forwarded to the steamer on the day of sailing, direct from the Cool Stores.

The four remaining cases were kept at Mr. Hatfield's, two in the ordinary fruit-room, and two in a well-ventilated chamber, cooled by the Meakin process. The intention was to examine each of the seven cases, when the *Osterley's* arrival in London was announced, and compare it with the report received as to the two cases forwarded to the Agent-General in London. The three cases

of Esopus Spitzenberg sent to Doncaster Cool Stores on 12th April, just as they were picked from the tree, and kept at a temperature of 30–32° Fahr., were opened on 27th May, about the time when the *Osterley* arrived in London, and examined with the following results :—

No. 1, containing 150 unwrapped apples, showed four distinctly pitted, but not to any great extent. The percentage of Pit was therefore 2·6.

No. 2, in which the apples were smaller than in the preceding, contained 195 wrapped apples, and with paper round case. There were five pitted, not badly, and the percentage was therefore also about 2·6.

No. 3 contained 155 apples, unwrapped, and they were all perfectly free from Bitter Pit.

At Mr. Hatfield's orchard the four cases retained were likewise examined, the two kept in ordinary storage being numbered 4 and 5, and the two under the Meakin process numbered 6 and 7. Of course the apples were not so firm and solid as those kept in cold storage.

No. 4 contained 214 apples, of which none were pitted.

No. 5 contained 133 apples, much larger than preceding, and therefore more likely to become affected. Of these, five were pitted, sometimes very noticeably, and the percentage was therefore 3·7.

No. 6 contained 170 apples, of which three were pitted very slightly. The percentage was therefore less than 2 per cent.

No. 7 contained 157 apples, of which 12, mostly large apples, were moderately pitted; the percentage was therefore 7·6.

All these cases were still kept under the same conditions as at first, every apple being free from any external marks of the Bitter Pit, and re-examined on 25th July, when the report was received from London.

Final Report on Esopus Spitzenberg Apples.

This variety was chosen because it is particularly liable to develop Bitter Pit in store. The fruit was picked in Mr. Hatfield's orchard, Box Hill, on 10th April, and nine cases were retained for experimental purposes.

Three cases were forwarded to Doncaster Cool Stores, to be kept at a temperature of 30–32° Fahr. The apples in two cases were unwrapped, just as they were picked off the tree, and, in the other, they were wrapped in paper and pre-cooled, the temperature being gradually reduced to 35–36° Fahr. before placing in cool chamber. Four cases were placed in Mr. Hatfield's fruit-room, just as they were picked.

Two cases were kept for sending to London, the apples being carefully wrapped in paper. One case was pre-cooled, and both were kept at a temperature of 30–32° Fahr. until they were forwarded on 18th April to s.s. *Osterley*, sailing for London on that date, and consigned to the Agent-General.

The s.s. *Osterley* arrived at Tilbury Docks on 25th May, being 37 days after leaving Melbourne. A report was received from the Agent-General, dated 12th June, and the seven cases retained here were examined on 25th July, or three and a half months after they were placed in store, and allowing sufficient time for them to have been sent to London and returned.

Cool Storage.—The three cases were carefully examined, apple by apple, by myself in the presence of Mr. French, Engineer-in-Charge, and Mr. Hatfield. Not a single apple showed Bitter Pit, and they were in good marketable condition. Although wrapping in paper prevents sweating, and those wrapped are usually superior in quality to the unwrapped, there was no appreciable difference in the few cases used in this experiment.

Fruit-room.—The four cases in ordinary storage were examined the same day, and, although the apples were saleable, it was very noticeable how shrivelled they were. A number had rotted, and, apart from the shrivelling, the pitted apples in each case were 1, 6, 6, and 3 respectively.

Shipment.—The Agent-General is of opinion that it would not be wise to regard the result of this experiment as satisfactory, inasmuch as, owing to the Dock strike, there was considerable delay in the delivery of the cases. Nevertheless, the report of the Inspector of Produce is here given, dated 12th June, when both cases were available for examination—

"In accordance with your instructions, I have this day examined, at your office, two boxes of apples, one shipped under ordinary conditions, and the other pre-cooled before shipment. These were sent per s.s. *Osterley*, which arrived at Tilbury Docks on 25th May. The one having the words pre-cooled on the card was delivered at your address on the 5th inst., and the other on the 12th, by J. B. Thomas, of Covent Garden Market. I examined every apple in both boxes, taking that marked pre-cooled first. I found many of them bruised, one rotten, and seven spotted with Bitter Pit; some were heated and over-ripe. In the other box I found most of them bruised, seventeen rotten, and eight affected with Bitter Pit. The bruises were not caused by pressure through tight packing, as neither box was full, and each would have at least twenty more apples than the box contained. The damage was caused through the apples being loose, and having undergone a lot of extra handling. The softness, sweating, and rotting were the effects of long exposure to a high temperature, inasmuch as the ship arrived on the 25th of May, and the boxes were not delivered till, in one case, twelve days, and the other sixteen days, after arrival, and under the conditions prevailing at the Docks, this is scarcely a fair test. I am strongly in favour of the system of pre-cooling."

The experiment will be repeated next fruit season, but the fact remains that apples liable to pit in store were kept for three and a half months at a constant temperature of 30–32° Fahr. without showing the slightest trace of Bitter Pit.

Cleopatra Apples.

Ten cases of Cleopatra apples were forwarded from Bathurst Experiment Farm by rail on 25th April, for purposes of experiment, and arrived in Melbourne on 1st May. They were at once sent to Doncaster Cool Stores. Seven cases at the Cool Stores were dealt with as follows:—Two cases were pre-cooled, being reduced to a temperature of 34–35° Fahr., and two cases were simply kept in store, preparatory to being forwarded to London. The other three cases were placed in cold storage under the dry-air system, at a temperature of 32° Fahr. The remaining three cases were taken to Mr. Hatfield, who placed two of them in a room cooled by the Meakin process, and one in the ordinary fruit-room.

On the way to Melbourne the cases were knocked about a good deal, and in order that the results might be quite comparable the apples in each case were examined and re-packed, all rotten and pitted fruit being rejected.

Shipment.—The four cases for London were consigned to the Agent-General, and forwarded per the s.s. *Afric*, which sailed on 16th May. They were specially reported on by the Inspector of Produce, under date 25th July, as follows:—

> "I beg to report that I have this day examined the contents of four special boxes of apples brought over by the s.s. *Afric*, which were landed on the 20th inst. I examined each apple separately in each case in the order named, with the following results:—
>
> No. 1.—I found 7 apples rotten and 5 pitted.
> No. 2.—I found 11 apples rotten and 10 pitted.
> No. 3.—I found 7 apples rotten and 6 pitted.
> No. 4.—I found 17 apples rotten and 2 pitted.

In every box some apples were wilted and shrivelled, but a greater proportion in numbers 1 and 4, and they were all more or less heated and sweating. I did not observe on the boxes any indication as to which had been pre-cooled or those that were shipped under ordinary conditions. This fruit had been subjected to a severe and unusual test, as the ship had been held up at Plymouth for nearly three weeks before she could proceed to Tilbury. In consequence of the strike, no berth could be found for her."

Cool Storage.—On receipt of the above report, the three cases in the Doncaster Cool Store were carefully examined in the presence of the Officer-in-charge and Mr. Hatfield. The apples were all marketable with the exception of three that had rotted in one case. An occasional pit appeared on the surface when carefully looked for, more particularly in the larger-sized apples. They had neither heated nor sweated, and, while not exactly shrivelled, some of them were " a little bit loose on the skin," as described by one of the examiners. On tasting the apples, they were found to have their full flavour.

Fruit-room.—The three cases in ordinary storage were examined the same day. The pitting was so slight that not a single apple was unmarketable from that cause, but some of them were slightly shrivelled, and a considerable proportion had rotted. In No. 1 case 17 per cent., No. 2 case 11 per cent., and No. 3 case 23 per cent. had rotted. As compared with those kept in cold storage, the apples were much more highly coloured, and had ripened. The flavour was first class.

Cold storage at a sufficiently low temperature has thus the effect of retarding changes in the fruit, such as ripening, shrivelling, and rotting. It was very noticeable that the fruit in the Cool Store remained about the same stage of ripeness as when it was put in, while that in ordinary storage had ripened considerably. In order to guard against the development of Bitter Pit, the apples should be picked when on the turn, as it were, just when they have reached their full size and on the green side, and placed in cold storage without delay.

General Results.

The results of these experiments clearly show that a sufficiently low temperature kept uniform retards the development of Bitter Pit, and, in order that apples should arrive at their destination in the same freedom from disease as that in which they were shipped, it is necessary to avoid fluctuating temperatures. There will require to be a linking up of cold storage from the vicinity of the orchard to the ship's hold. The fruit should be pre-cooled to the necessary temperature in the cool store of the district as soon as possible after picking, then placed in cold air trucks, and conveyed to the wharf, where it should be kept in cold storage, and then loaded.

By adopting this thorough system of keeping the fruit uniformly cool, the development of Bitter Pit in transit will be a thing of the past.

It is satisfactory to find that this is also the experience in the United States, for F. W. Morse (113) in his Bulletin on "Chemical Changes in Apples during Storage," writes:—"It is evident, therefore, that the lowest possible temperature at which apples may be kept without freezing is necessary to most effectively retard changes in the fruit, which are entirely independent of the attacks of fungi, but are the results of activity within the cells of the apple itself."

During the past season there have been numerous complaints regarding Bitter Pit in the fruit shipped, and I will take as an example the report of a Hamburg firm on 7,455 boxes of Australian apples shipped by s.s. *Oberhausen*, and sold in Hamburg on 23rd April. "Bitter Pit was very much in evidence, more than we have ever seen before. Some lots looked terrible, and again Munroe's Favorites showed it more than any other variety. However, many lots of Cleopatras, Dunn's Seedlings, Five Crowns, Esopus Spitzenbergs, Reinettes de Canada showed it as well; while Jonathans were not so badly affected. The most affected lots originated from Victoria, but

there were also quite some from South Australia, and we noticed it also on Cleopatras from West Australia. This Bitter Pit is a very serious question, and is threatening the success of the industry, and growers and shippers should unite in finding out if this disease could be prevented."

The experiments now being conducted in cold storage have a very important bearing on this point. When fruit is kept at a temperature of 30–32° Fahr. on the dry-air system, and free from Pit when it is stored, it remains practically clean, that is to say, that if clean fruit is shipped, it should arrive at its destination practically clean. There is scientific as well as practical sanction for this statement.

We have seen that the fruit, even when detached from the parent tree, still goes on respiring, and the activity of this process is considerably modified by the temperature. There is a lower limit, at or beyond which it seems to be suspended, although life is not destroyed, and, while this limit varies in different plants, it is generally one or two degrees below the freezing point of water. So the apple, at this temperature, is in a state of suspended animation, and any development of Pit is retarded.

There is no reason why fruit should not be carried at this temperature on board ship, and I have the authority of one of the engineers for stating that the temperature can be kept constant to within half-a-degree. I would strongly recommend that it become a regular practice in each exporting State to have sample cases from each consignment placed in cold storage here and compared with the condition of the shipment on its arrival in London. Both could be examined about the same time (the arrival of the fruit ships being noticed in the daily press), and the results obtained under known conditions compared with those from the conditions on board ship.

As showing how Bitter Pit develops in ordinary storage, the following experiment is instructive.

Six apple trees of the variety known as Annie Elizabeth were selected at the Burnley Horticultural Gardens for testing the amount of Bitter Pit present in the crop when ready for picking, and the effect of keeping the fruit, which did not develop the disease externally while still on the trees. The fruit was gathered on 4th March, and there were 237 apples altogether, of which 160 were pitted and 77 sound. The sound apples from each tree were placed in separate cases, and kept in my laboratory. They were examined successively on 15th, 23rd, and 30th March, when the diseased were removed, and the following is the result :—

Tree No.	4th March.		15th March.		23rd March.		30th March.	
	Pitted.	Sound.	Pitted.	Sound.	Pitted.	Sound.	Pitted.	Sound.
1 ..	30	12	1	11	9	2	2	0
2 ..	25	17	3	14	10	4	2	2
3 ..	40	6	1	5	3	2	0	2
4 ..	30	0	..	..	..	..	..	..
5 ..	5	3	2	1	0	1	0	1
6 ..	30	39	0	39	18	21	4	17
Total ..	160	77	7	70	40	30	8	22

Seven of the apples, which were apparently sound when taken from the tree, developed Pit in 11 days, 40 more in 19 days, and 8 in 26 days; so that there only remained 22 sound apples at the end of the month out of a total of 77 at the start.

The percentage of sound apples, while the fruit was still on the trees, amounted to 32.5, but, after being picked and kept for nearly four weeks, it was only 9.2, or about 91 per cent. of the total yield was pitted.

G.—MISCELLANEOUS.

Ringing or Cincturing.

Now that so much attention is being directed to Bitter Pit, orchardists themselves are experimenting in various ways. The theory is very generally held that it is due to an overflow of sap, and an evident means of reducing this is to cincture or ring the trunk or branches of the tree. A New South Wales grower has observed a decided improvement during the past season as a result of twisting several turns of wire round the trunk, especially in the Northern Spy variety, which is particularly liable to Bitter Pit. He asserts that there has been a better setting of fruit and more even ripening. Others have tried it without any apparent effect, but a single season cannot give a conclusive test, and in neither case has a definite comparison been made between a cinctured and a normal branch on the same tree. It must be remembered, too, that the result will depend on the particular stage of growth of the tree, as it is generally considered to be most effective on very vigorous shoots, so that the wound may be quickly healed or the compression readily overcome.

When a branch is constricted with a ring of wire, the growth of the wood is altered by the compression of the fibres. Afterwards, the wire is enveloped by the new growth, the outer layers are ruptured, and a soft wood is produced. In the vicinity of the wire a black discoloration may be observed, due to the chemical combination of tannic acid with the iron. It is the new wood formed as a result of the compression which constitutes the principal conducting tissue for the upper portion of the branch. This operation is generally considered to cause an early death of the branch, and the experiment will be tried simply to test the effect of the earlier ripening of the fruit on the development of Bitter Pit.

A tree of the Annie Elizabeth variety has been selected, with suitable spreading branches, and the ringing will be performed on different branches of the same tree in June, July, August, and September, and the wire removed after the fruit is picked. A tree of the same variety will be cinctured, and the experiment carried out on similar lines.

In the Queensland *Agricultural Journal* for May, 1912, it is noted that "Experiments made at the Experimental Station at Bologna (Italy) have shown that by removing the bark in rings from the branches of peach trees the fruiting is greatly encouraged, and the fruit is finer and ripens more quickly than those of trees not so treated. The tree is not injured by this operation, and the fruit is even more firmly attached to the branches." Mr. Pescott also informs me that he very successfully "ringed" peach trees ten years ago, the ringing of each limb with fencing wire giving excellent fruiting growths and fruit as well. The cincturing of currant vines is likewise regularly practised, but it remains to be seen how far this operation will affect the development of Bitter Pit.

Bending of Branches or Leaving the Laterals Unpruned.

When shoots are in their natural position, and more or less vertical, the water supply is mainly directed towards the buds near the apex, but, when the shoot is bent and an arch formed, the highest point of the arch will receive the greatest amount of nutritive material. The under surface of such a bent shoot is thrown into folds and wrinkles, because the outer tissues are compressed into a smaller space. This lateral compression causes the outer tissues to split away from the internal wood, and a layer of young wood is formed, rich in starch. The tension of the upper surface causes the cells to stretch and become narrower, so that the flow of sap is diminished towards the apex. The result is that the bending of the shoot interferes with the ascending and descending currents. Above the bend there is an accumulation of formative material, and the buds there are most likely to develop into flower-buds. Below the bend the buds receive a more liberal supply of water, and develop into leafy shoots.

The side shoots of a tree, when bearing fruit, are generally bent down by the weight of it, and this bending of the shoot will exercise an influence on the supply of food material. These side shoots when they have made fairly long and rapid growth are known as Laterals, and the question is, what effect has the pruning of the laterals on the development of Bitter Pit?

Of course, there are a number of orchardists who consider that pruning has no influence on Bitter Pit, but, if we take the opinion of those who have specially referred to it in their replies to questions, it is found that lateral pruning is not recommended. In Victoria, the following replies have been received :—"I think light pruning makes a great difference in the amount of Pit, leaving plenty of lateral growth." "To leave most of the long laterals with fruit spurs attached is beneficial." "I have always pruned with plenty of laterals, and have had less pit than my neighbours." "When laterals are left long or unpruned altogether (if not too long) a larger percentage of clean fruit will result." "Prune lightly, leaving laterals to run sap off, and the disease is lessened 75 per cent." "I fancy it is the chief thing to get *bends* in the leaders, and do away with the upright ones as much as possible, and encourage laterals. It exhausts the rapid flow of sap, and the fruit matures gradually." "I find in Cleopatras leaving their fruit on the long laterals reduces the disease wonderfully."

In New South Wales, no special reference is made to it, and in South Australia it is indirectly referred to. "I left one tree in the middle of 2 acres of Cleopatras unpruned for ten years, and picked more clean apples from that one in a bad season than from ten of the heavily pruned trees." "The harder trees are pruned the more subject they are to Pit, but a great deal depends on the method of pruning and treatment of laterals." In West Australia, it is not noted; and in Tasmania the direct question was sent out to various Fruit-growers' Associations by the Director, viz., "Have you found any appreciable effect in the diminution or otherwise of Bitter Pit from the retention of lateral branches when pruning?" Out of eleven replies received, four found no difference, and the remaining seven found less Pit on the left laterals. "I always retain in pruning lateral branches and spurs, and, as a rule, do not lose in 2,000 bushels 1 per cent."

In a paper on "Lateral Growths," read before the Clarence Board of Agriculture by Mr. Goodwin (35), it was stated and concurred in by several of the growers present that Bitter Pit had never been found in an apple at the end of a lateral shoot. This is not always so, as I found one of the Garden Royal variety at the Burnley Gardens. The tree yielded about a bushel case of fruit, and it was the only apple on the tree with Bitter Pit. It was the only fruit at the end of the lowest lateral out of one of the main branches, but it is generally the case that the terminal fruit, at least, on laterals is free from Bitter Pit.

In conclusion, the Principal of the Burnley School of Horticulture approves of the retention of a good lateral system, and only prunes the lateral growths—

(1) When they interfere with each other;
(2) When they are overcrowded;
(3) When they are too high in the tree; and
(4) When they have a long unproductive reach near to the main limb.

But the relationship between this practice and Bitter Pit has yet to be determined by exact observation and experiment.

The experiments here mapped out and already begun may be extended as found necessary. It is evident, however, from the very nature of the case, that the results of these experiments may modify the views expressed, and visits paid to the various States during the growing season may bring a number of new facts to light. But I considered it desirable and profitable, even at this early stage of the inquiry, to show the progress made "as far as my investigations go."

The experiments have at least one advantage, apart altogether from their bearing on Bitter Pit, that each one of them will throw light upon a number of horticultural practices which aim at the production of good yields and high quality. They will also advance our knowledge of cultivation, manuring, pruning, stocks, irrigation, and cold storage in relation to fruit production and keeping quality, and be for the general benefit of the fruit-growing industry of Australia.

I cannot sufficiently express my appreciation of the facilities afforded in each State by the Heads of the respective Agricultural Departments in furtherance of the objects of this investigation. Each one seemed to vie with the other in assisting me in every possible way, and I was made to feel, when visiting each State, that I was regarded as an officer of that Department for the time being, seeking to benefit the fruit industry of the Commonwealth as a whole. The services of the horticultural experts were also freely placed at my disposal, so that the investigation became more of a co-operative undertaking than merely one of individual effort.

Mr. C. C. Brittlebank, of the Vegetable Pathologist's Branch, Victoria, has been of great assistance to me in the Laboratory, and has supplied the great majority of the striking photographs here reproduced.

To the horticultural press I also owe a debt of gratitude for the sympathetic tone adopted, and for contributions on the subject of practical interest.

And, lastly, I am indebted to Messrs. Cuming, Smith and Co. for gratuitously supplying all the manures required for experimental work.

SUMMARY.

It is a fundamental principle of pathology that the normal structure and functions of the part or organ concerned should be determined as far as possible, in order that the abnormal conditions may be properly understood.

The structure and functions of the apple and pear were therefore investigated, with the result that, on the removal of the skin and flesh after softening, there remained a delicate skeleton and vessels as a model of the whole, ramifying through and permeating every portion of the fruit, supplying the seed-vessels and the flesh with liquid nourishment, and forming a network of vessels immediately beneath the skin. This vascular network was found to originate in the earliest stages of the fruit, and continues to expand with the enlarging flesh.

It is shown that neither insects nor fungi, bacteria, nor external agencies, such as spraying, are concerned in the production of Bitter Pit.

Bitter Pit is seen to be an internal disease, due to internal causes, and always found associated with the discoloured vascular bundles.

"Crinkle," or "Pig Face," or "Hollow Apple" is shown to be a confluent form of Bitter Pit, every gradation being observed from pit to slight and advanced crinkle. Large cavities are formed by the rupture of the tissue, owing to rapid and excessive growth at the periphery.

Diseases found associated with Bitter Pit were "Black Spot," "Bitter Rot," "Glassiness" or "Water Core," and "Mouldy Core."

Appearances mistaken for Bitter Pit were hail-marks, bruised skin, effects produced by chemical reagents, and local poisoning.

Pitted Apples are produced on unsprayed trees, and a chemical analysis of such apples revealed no trace of mineral poisons.

It was found, as far as my investigations go, that the key to the solution of the Bitter Pit problem lay in the wonderful vascular system which permeates the "core" and the "flesh," and the marvellous network of vessels just beneath the skin, their function being to regulate and equalize the distribution of food material at the periphery of the fruit, where the greatest and most rapid growth normally takes place.

The brown spots of Bitter Pit are generally first formed in the zone occupied by the vascular net, of which there is not only ocular demonstration in the position of the tough brown spots still

adhering to the apple in which the network is shown (Fig. 90), but in the figure of the apple reproduced direct from the object itself. (Frontispiece).

There is also a striking confirmation of this in the fact that the same place of origin of the brown spot has been noted by competent observers in Europe, America, and Africa, even although the existence of the network was unknown to them.

The earliest external appearance of Bitter Pit was noticed when the fruit was about the size of a walnut, but it generally occurs when the fruit is about half grown or approaching maturity.

It generally occurs in the upper half of the fruit and towards the "eye" end, and this is correlated with the openings in the skin being much more numerous in the upper than in the under portions. Chemical analysis shows that there is less water in the flesh of the upper portion.

The larger number of openings will necessarily allow more active transpiration to go on at the "eye" end than at the stalk end, and, owing to this extra transpiration, there is less water in the flesh at the top.

Bitter Pit may be associated with wet or dry seasons, so long as they are intermittent and fluctuating in their character at the critical period of growth.

The principal contributing factors to Bitter Pit are :—

(1) Intermittent weather conditions when the fruit is at a critical period of growth.
(2) Amount and rapidity of transpiration.
(3) Sudden checking of the transpiration at night, when the roots are still active owing to the heat of the soil.
(4) Failure of supplies at the periphery of the fruit, followed by spasmodic and irregular recovery.
(5) Inequality of growth, so that the vascular network controlling the distribution of nutritive material is not regularly formed.
(6) Fluctuations of temperature when fruit is in store ; and
(7) Nature of variety.

The weather cannot be controlled (except in so far as a smoke-blanket is allowed to drift over the orchard on frosty nights), but the soil and the tree and the fruit formed may be controlled to a large extent by cultivation, manuring, including green manuring, irrigation, the stocks used, and the method of pruning.

The relation of each of these factors to the development of Bitter Pit is being determined by means of experiments.

Young and vigorous trees making rapid growth may have pitted fruit, from the rapid transpiration and excessive growth interfering with the regular development of the vascular network.

A light crop, with abnormally large fruit, is more liable to pit than a heavy crop of average sized fruit, equally distributed over the tree.

The apple, pear, and quince are subject to Bitter Pit, but, apart from the larger number of apples and pears grown relatively to the quince, the latter is least liable. The woolly covering of hairs on the fruit reduces transpiration, and the quince is the only one of these three fruits which retains the hairy covering at maturity.

Certain varieties of apples develop Bitter Pit in store when subjected to a fluctuating temperature and humid conditions.

When apples, even very susceptible varieties, are kept at a temperature of 30–32° Fahr., the development of Bitter Pit is retarded.

There is a scientific explanation for this in the fact that there is a lower limit of temperature beyond which respiration is suspended, and this is generally one or two degrees below the freezing point of water. So the apple at this temperature is in a state of suspended animation.

The delicate structure of the apple and its abundant supply of vessels show the necessity for careful handling and skilful packing for export.

LITERATURE DIRECTLY RELATING TO BITTER PIT.

1. ALLEN, W. J. Orchard Notes—April. *Agricultural Gazette*, New South Wales, XII., p. 509. 1901.
List of varieties affected.

2. ——— Orchard Notes—July. Ibid., XXIII., p. 640. 1912.
Experiments recommended for controlling this trouble—liming, watering, drainage, spraying with lime and sulphur solution, and pruning.

3. ALLISON, J. Treatment of Bitter Pit in Apples. *Agricultural Gazette*, New South Wales, IX., p. 561. 1898.
Spraying with Bordeaux mixture said to be effective.

4. ANONYMOUS. The Cause of Bitter Pit. *Queensland Agricultural Journal*, p. 84. August, 1911.
Various theories given, but that of spraying with arsenate of lead specially referred to.

5. ——— Bitter Pit. *South Australian Journal of Agriculture*, XV., No. 2, p. 120. September, 1911.
Record of experiments being conducted at Government Experiment Orchard at Blackwood.

6. ——— Ergebniss der Rundfrage nach stippigen Apfelsorten. *Der praktische Ratgeber im Obst-und Gartenbau*, p. 143. April, 1909. Frankfurt.
Results of replies to questions concerning Bitter Pit from 107 German orchardists.

7. BENSON, A. H. Apple Culture—Bitter Pit. *Agricultural Gazette*, New South Wales, V., p. 408. 1894.
Said to be spreading rapidly in the Colony, and no remedy can be suggested.

8. BOWLES, E. A. (AND OTHERS). Bitter Pit in Apples. *The Journal of the Royal Horticultural Society*, XXXVII., Pt. III., p. ccxvi. March, 1912.
Disease particularly prevalent, even among hard-fleshed apples, this season (1911). "No fungi or bacteria have been found connected with it, and it appears to be a disease of physiological origin rather than due to any parasite."

9. BROOKS, C. The Fruit Spot of Apples. *Bulletin, Torrey Botanical Club*, XXXV., p. 423. 1908.
Fruit pit and fruit spot distinguished, the former due to abnormal physiological conditions and the latter to *Cylindrosporium pomi*, Brooks. Vascular system of apple represented.

10. ——— Some Apple Diseases—Fruit Pit. New Hampshire Sta. Bull. 144, p. 119. 1909.
The disease described and illustrated. "Nothing definite can be given as to prevention."

11. ——— Fruit Spot of Apple. Duggar's *Fungous Diseases of Plants*, p. 341. Ginn and Co., London, 1911.
The Fruit Spot due to *Cylindrosporium pomi* is described, but it is noted that "the 'Stippen' disease, long known in Europe, and now reported from several parts of the United States, is regarded as entirely distinct, and probably not of fungous origin."

12. CARMODY, P. J. Bitter Pit. Report, Department of Agriculture, Victoria, 1907–10, p. 211. Government Printer, Melbourne, 1910.
Principal contributing causes given—susceptibility, over-developed fruit, unevenly developed fruit, excessive nitrogenous manures, and faulty pruning.

13. CLINTON, G. P. Baldwin Spot. Report of Connecticut Agricultural Experiment Station, 1903, p. 302.
"It is generally considered a physiological trouble, possibly resulting from too great loss of water at these places."

14. ——— Baldwin Spot. Ibid., Part VII., p. 589. 1910.
A physiological disease, but cause unknown.

15. COBB, N. A. An Obscure Disease. Another Obscure Disease of the Apple. *Agricultural Gazette*, New South Wales, III., pp. 284 and 1004. 1892.
Fungus and punctures of insects mentioned as probable causes.

16. ——— Bittter Pit of the Apple. Ibid., VI., p. 859. 1895.
Name of Bitter Pit first suggested.

17. Cobb, N. A. Cause of an important Apple Disease. Ibid., VIII., pp. 126 and 221. 1897.

The woolly-aphis is suggested as a possible cause, and it is also suspected that the disease is transmitted by grafting.

18. ——— Bitter Pit. Ibid., IX., p. 683. 1898.

No evidence to prove disease caused by fungus.

19. — — Letters on the Diseases of Plants—Stigmonose. *Agricultural Gazette*, New South Wales, XIV., p. 692, 1903; and Department of Agriculture, New South Wales—Miscellaneous Publication, No. 666, p. 38. 1904.

Bitter Pit and other obscure diseases of the apple, probably a kind of Stigmonose.

20. Cooke, M. C. *Fungoid Pests of Cultivated Plants*—Apple Brown Spot, p. 118. London, 1906.

"Surface of the fruit and interior marked with brown spots. Cause unknown."

21. Cotton, A. D. Bitter Pit of Apples. *Kew Bulletin*, No. 10, p. 401. 1910.

Refers to two important communications on the subject by Pole Evans and Lounsbury.

22. Craig, J. A Dry Rot of Apples. Canada Exp. Farms Report for 1896, p. 171. 1897.

The description and drawing show the disease to be Bitter Pit.

23. Crawford, F. S. Report on the Fusicladiums, the Codlin Moth, and certain other Fungus and Insect Pests attacking Apple and Pear Trees in South Australia, p. 53. Government Printer, Adelaide, 1886.

Under the heading of "Spotted Apples" this disease is fully described, and the opinion of a fruit-grower is given that it is due to the trees being young and making too much sap when planted in a damp situation. It is also noted that certain varieties are subject to spots when a short crop.

24. Davies, R. A. Bitter Pit in Cape Apples. *Kew Bulletin*, No. 4, p. 142. 1907.

Disease of a purely physiological nature, found on trees grafted on "French Crabs" and other stocks, as well as "Northern Spy." In the Transvaal, natural varieties which reproduce themselves truly are all immune.

25. Delacroix, G. *Maladies des plantes cultivées, Maladies non parasitaires*—"Points bruns de la chair des pommes." Office des Renseignements Agricoles. Paris, p. 275. 1908.

Apparently the first reference to this disease in France.

26. Despeissis, A. *The Handbook of Horticulture and Viticulture of Western Australia*—Bitter Pit, p. 506. Government Printer, Perth, 1903.

In Western Australia trees badly affected in damp localities on the plains hardly ever show the disease on well-drained soils and on the gravelly slopes of the Darling Ranges.

27. Diakonoff, H. In Russland beobachte Pflanzenkrankheiten. *Zeitschr. f. Pflanzenk.* XX., Pt. 8, p. 464. 1910.

Bitter Pit found in various districts of Russia.

28. ——— Stippigkeit der Aepfel. Ibid., p. 482. 1910.

The disease is a consequence of too rapid growth of individual groups of cells of the flesh, and wherever the conditions are very favorable to hastening the ripening process, either on the tree or in store, there it occurs.

29. Elkins, D. Bitter Pit in Apples. *The Garden*, LXXVI., p. 142. March 23, 1912.

Reply to letter, giving information as to rainfall, &c.

30. Eustace, H. J. A Core Decay of Baldwin Apples. New York Agricultural Experiment Station, Geneva. Bull. 235. July, 1903.

Reference to Baldwin Fruit Spot. Conditions which favour its development not the same as those which favour the development of core decay.

31. Evans, I. B. P. Bitter Pit of the Apple. Transvaal Department of Agriculture. Technical Bulletin, No. 1. Pretoria 1909.

The main factors believed to be responsible for the spotting are excessive transpiration during the day followed by its sudden checking and complete abeyance during the night, when root action is still vigorous owing to the warmness of the soil. The theory is propounded of the bursting of the cells due to too great internal pressure, with the result that the dry and tough Bitter Pit spots are formed.

32. Ewart, A. J. On Bitter Pit and the Sensitivity of Apples to Poisons. Proceedings, Royal Society, Victoria, XXIV. (N.S.), Pt. II. 1912.

"On three points, however, it may, I think, be stated with confidence that we are on a solid bedrock of established fact, namely, that Bitter Pit is, strictly speaking, not a disease at all, but is a symptom of local poisoning produced in the sensitive pulp cells of the apples, that more than one poison may produce it, and that such poisons may be derived from more than one source."

33. Farmer, J. B. Bitter Pit in Cape Apples. *Kew Bulletin*, No. 6, p. 250. 1907.

"All attempts to establish a fungal or bacterial origin for the disease failed. The cells of the affected area are always full of starch, and stand out in this respect in marked contrast to the surrounding healthy tissue."

34. FULTON, H. R.; WRIGHT, W. J.; GREGG, J. W. The Control of Insects and Diseases affecting Horticultural Crops. Pennsylvania Agricultural Experiment Station. Bull. 110, p. 15. 1911.

Under the heading of Fruit-spot it is stated, "It must not be confused with Fruit-pit, a different trouble, for which no successful method of control is known."

35. GOODWIN, W. A. Lateral Growths. *Agricultural Gazette*, Tasmania, XIX., p. 382. July, 1911.

"He had never found an apple at the end of a lateral shoot to have Bitter Pit." [Pitted apples have been found at the end of lateral shoots.]

36. GREIG-SMITH, R. Note on Bitter Pit of Apples. Proc. Linn. Soc., New South Wales, XXXVI., No. 141, p. 158. 1911.

No microbes nor fungi found, and suggests that the pits are the result of some enzyme or poison injected by sucking insects.

37. GRIFFON, E., AND MAUBLANC, A. Contribution a l'etude des Maladies des Pommes et des Poires. Annales de l'Institution National Agronomique, 2nd Ser., Vol. X., Part I., p. 9. 1911.

Under the heading of "Corky disease or brown spots in the flesh of the Apple" a brief description of the disease is given. Practical orchardists consider that nitrogenous manures favour it.

38. GRIFFITHS, A. Bitter Pit in Apples. *Agricultural Gazette*, Tasmania, XIX., p. 290. June, 1911.

Bitter Pit is regarded as a constitutional weakness in the fruit itself and is directly due to overgrowth. The remedies are, apart from rainfall, over which we have no control:—(1) proper drainage of land; (2) judicious manuring; (3) avoid excesses in pruning; (4) when irrigating be temperate.

39. GÜSSOW. H. T. *Journal, Royal Agricultural Society*, England, LXVII., p. 259. 1906.

Varieties found affected in England, Warner's King, New Hawthornden, Lord Grosvenor, and Allington Pippin—all soft fleshy fruits. Injury only detected after storing.

40. ——— Report of the Dominion Botanist—Fruit Pit or Bitter Pit of Apples. Canadian Experiment Farms Report, p. 244. 1911.

Description of the disease, with a good illustration, and the cause discussed, but no definite conclusion arrived at. "The causal factors are, on the one hand, rapid loss of water from the fruit, and, on the other, an inability to make good this loss with sufficient rapidity."

41. JAEGER. *Illustr. Monatshefte für Obst-und Weinbau*, p. 318. 1869.

Pitting developed in liable varieties by rapid transpiration.

42. JONES, L. R. Fifth Annual Report, Vermont Agricultural Experiment Station, p. 133. 1891.

Occurrence of a fruit spot of the Baldwin apple mentioned.

43. JONES, L. R., AND ORTON, W. A. The Brown Spot of the Apple. Twelfth Annual Report, Vermont Agricultural Experiment Station, p. 159. 1899.

The spots were associated in their distribution with that of the vascular bundles, occurring at or near the ends of the veins which ramify in the flesh of the fruit. Summary of causes assigned and remedies suggested.

44. KIRCHNER, O., AND BOLTSHAUSER. Stippigwerden der Aepfel. *Atlas der Krankheiten*, Series V., Plate XXVIII. Stuttgart, 1899.

The illustration shows the brown spots beneath the skin, and the disease is probably caused by the gradual loss of water from the transpiration of the fruit.

45. KIRK, T. W. Bitter Pit. Sixth Annual Report, Department of Agriculture, New Zealand, p. 186. 1898.

States that the loss inflicted is considerable.

46.——— Bitter Pit of Apples. Nineteenth Annual Report, Department of Agriculture, New Zealand, p. 164. 1911.

Varieties affected given.

47. LAFAR, F. Technical Mycology, I., p. 403. Griffin and Co., London, 1898.

Brown spotting or spotting of sound apples under the rind is said to be due to the cells becoming ruptured, and oxidation of the tannin being produced.

48. LAMSON, H. H. Fruit and Potato Diseases. New Hampshire College Agricultural Experiment Station. Bull. 45. May, 1897.

Spot disease of Baldwin apple referred to. Considers that spraying with Bordeaux mixture reduces amount of spotted fruit.

49. LEA, A. M. Bitter Pit. Department of Agriculture, Tasmania. 1903.

Regards this disease of apples in Tasmania as being the most troublesome, next to Black Spot.

50. LOUNSBURY, C. P. The Fusicladium Disease of the Pear and Apple. *Agricultural Journal*, Cape of Good Hope, Cape Town, XXXIII., p. 16. 1908.

Bitter Pit referred to and illustrated because commonly confused with Fusicladium.

51. Lounsbury, C. P. Bitter Pit. Ibid., XXXVII., p. 150. 1910.

Gives a collection of data obtained from various sources dealing with storage, stocks, varieties, irrigation, manuring, and pruning. The susceptibility of different varieties in various parts of the world is also given, obtained from responsible authorities.

52. Macoun, W. A. "Dry Rot," "Brown Spot," or "Baldwin Spot" of the Apple. Canada Experiment Farms Reports, p. 96. 1899.

The disease described and the conclusions reached as the result of questions sent out to prominent fruit-growers in Canada and to the horticulturists of all the Agricultural Experiment Stations in the United States. "No remedy has yet been found for this trouble."

53. Martin, T. C. (and others). Report of the Scottish Agricultural Commission to Australia, 1910–11, p. 264. Wm. Blackwood and Sons, Edinburgh and London. 1911.

"A mysterious disease of the apple, called Bitter Pit, is not uncommon. The fruits affected are spotted with brown pits, and a somewhat bitter flavour is imparted to the flesh. The ailment is associated with unhealthy cultural conditions."

54. Massee, G. Apple Disease. *Kew Bulletin*, No. 6, p. 193. 1906.

Disease of a purely physiological nature, and injury considered to be due to fruit being subjected to too high a temperature during first period of ripening.

55. ——— *Diseases of Cultivated Plants and Trees*, pp. 64 and 571. London, Duckworth and Co. 1910.

Referring to Pole Evans' method of overcoming the Bitter Pit difficulty by raising South African seedlings in the localities where the fruit is to be grown, he remarks :—" I am afraid this is somewhat cold comfort, considering the fact that Bitter Pit is often rampant in Europe on the offspring of trees that have had ample time to become acclimatised."

56. Maynard, S. T. Report of the Horticulturist, Massachusetts, Hatch Station Report. 1898.

"The Baldwin apple has in many places in the last two or three years shown so great a tendency to the dry-rot spots under the skin long before its normal time for the breaking-down of the tissues in the process of ripening, that much of its fruit put on the market has had the effect of decreasing the demand and lowering the price."

57. McAlpine, D. Report on Diseased Apples—Bitter Pit and Crinkle. Guides to Growers, No. 48. Department of Agriculture, Victoria, p. 4. April, 1901.

Both these diseases are described, and liable varieties given.

58. ——— Crinkle and Bitter Pit of the Apple. *Journal, Department of Agriculture*, Victoria, I., p. 804. 1902.

Experiments with manures decided on, and a word of warning uttered regarding the presence of brown dry spots in Australian apples in London, sometimes incorrectly referred to as Black Spot.

59. ——— Report of the Vegetable Pathologist—Bitter Pit. *Journal, Department of Agriculture*, Victoria, II., p. 851. 1904.

Bacteria not the cause, according to Dr. Bull, Bacteriologist of the Melbourne University.

60. ——— Vegetable Pathologist's Branch. Report, Department of Agriculture, Victoria, 1905–7, p. 37. 1907.

Effect of various manures on the development of Bitter Pit referred to.

61. ——— Report on "Bitter Pit" of the Apple. *Journal, Department of Agriculture*, Victoria, VII., p. 439. 1909.

Nature, symptoms, and distribution of disease given, together with varieties affected and recommendations.

62. ——— Bitter Pit of the Apple. Ibid., VIII., p. 201. 1910.

Results of manurial experiments with Prince Bismarck, a very liable variety of apple, and effect of keeping the fruit in store.

63. ——— Bitter Pit in Apples. *The Garden*, LXXVI., p. 119. March 9, 1912.

Letter asking for information as to rainfall during season 1911, when Bitter Pit was extremely prevalent in England.

64. McEwin, H. *The Fruit-growers' Handbook*, p. 135. Launceston, Tasmania, 1910.

After discussing various theories, it is concluded that the disease is worse in a dry year and in a light crop, and that it may be caused by the lack of some substance or constituent in the sap.

65. Meeking, E., and Booth, R. T. The Fruit Export Trade to the United Kingdom and Europe. *Journal of Agriculture*, Victoria, VIII., p. 520. 1910.

Marked diminution of "Bitter Pit" in shipments.

66. MORSE, W. J., AND LEWIS, C. E. Maine Apple Diseases—Baldwin Spot. Maine Agricultural Experiment Station, Twenty-Sixth Annual Report. Bull. 185, p. 349. 1910.

The distinction between Fruit Spot due to *Cylindrosporium pomi* and Fruit Pit, the cause of which is unknown, is pointed out, and it is remarked that "The observations of the writers have convinced them that the Baldwin Spot is of common occurrence in Maine, and that apples affected by this disease are more seriously injured than are Baldwin apples affected by the fungous disease."

67. NORTON, J. B. S. Water Core of Apple. *Phytopathology*, I., No. 4, p. 126. 1911.

"Evans attributes Bitter Pit of apple in Africa to conditions somewhat similar to those here considered to be associated with water core."

68. O'GARA, P. J. Absorption of Arsenic by Apples from Spray. *Better Fruit*, p. 28. February, 1911.

Spotting believed to be caused by arsenate of lead quite distinct from "Baldwin Spot."

69. OSBORNE, J. Bitter Pit in Apples. *Agricultural Gazette*, Tasmania, XVIII., p. 282. December, 1910.

Agrees generally with theory advanced by Pole Evans. Deals with development in storage, effect of stock, influence of soils, water supply, irrigation, effect of pruning, and influence of age on trees.

70. QUINN, G. The "Brown or Bitter Pitting" Defect in Apples. *South Australian Journal of Agriculture*, VIII., No. 6, p. 305. January, 1905; and Bulletin, No. 7, 1905.

Comparative immunity of varieties commonly met with in South Australian orchards given. Suggestions made as to treatment of trees and selecting scions.

71. ——— Report of the Minister of Agriculture, 1909–10, pp. 43, 44. Government Printer, Adelaide, 1910.

Bitter Pit in apples observed in the following districts:—Kalangadoo, Angaston, and Clare.

72. ——— Report of the Horticultural Instructor and Chief Inspector of Fruit, 1910–11. Government Printer, Adelaide, 1912.

Bitter Pit experiments described, the tests including the effect of different stocks, combination of stocks, manuring, pruning, cultivation, and irrigation.

73. REICHELT. Das Stippichwerden der Aepfel. *Pomologische Monatshefte*, p. 335. 1884. Stuttgart.

Disease attributed to a fungus, and the bitter taste probably due to Diacetyl grape sugar.

74. ROBINSON, H. Bitter Pit and the Fruit Industry. *Agricultural Gazette*, Tasmania, XIX., p. 479. September, 1911.

Experience showed that Bitter Pit may be caused by incorrect methods of pruning, by the injudicious use of fertilizers, or by the want of a complete fertilizer.

75. SCHNEIDER. Stippige Apfel. *Prakt. Ratgeber f. Obst-und Gartenbau*, p. 21. 1909.

Disease occurs on sunny and shady side, also on young and old trees. Years with great and sudden changes of temperature favour the disease.

76. SCIENTIST. Bitter Pit in Apples. *The Garden*, LXXV., p. 581. December 2, 1911.

Observes that the disease has been extremely prevalent during the past year, not only in soft-fleshed varieties, but to a much less extent in hard-fleshed lots. Suggests that possibly there was an accumulation of tannin or malic acid in certain spots causing death of cells.

77. SCOTT, W. M. A New Fruit Spot of Apple. *Phytopathology*, I., No. 1, p. 32. February, 1911.

Chemical tests support the suspicion of arsenic injury, but cannot be considered conclusive evidence. "The spots develop mostly, if not entirely, after the fruit is picked and while in temporary or cellular storage, *en route* to market; or after it is removed from cold storage. Low temperatures retard or prevent its development, and the trouble may be avoided in part at least by placing the fruit in cold storage as soon after picking as possible."

78. SELBY, A. D. Some Diseases of Orchard and Garden Fruits—Brown spots beneath skin of apple. Ohio Agricultural Experiment Station. Bull. 79, p. 135. 1897.

Refers to specimens sent from Ottawa, Canada, and states that the same trouble is reported in Ohio upon Northern Spy, and perhaps upon other varieties.

79. ——— A brief Handbook of the Diseases of Cultivated Plants in Ohio—Apple. Ohio Agricultural Experiment Station. Bull. 214, p. 369. 1910.

The Brown Spot or Dry Rot of Baldwin and other varieties of Apple is referred to as frequent, and the causes of the internal spotting must in part be regarded as physiological breakdown.

80. SEUFFERHELD, H. Betrachtungen ueber das Stippigwerden der Aepfel. *Mitteilungen ueber Obst-und Gartenbau*, p. 165. Geisenheim. 1900.

Liable varieties are those with large fruits, which are protected against excessive transpiration by a smooth skin. He considers that rough-skinned freely transpiring sorts are not liable even when the fruits are large.

81. SMITH, R. E. Baldwin Spot. Report of the Plant Pathologist, California Agricultural Experiment Station, Berkeley. Bull. 203, p. 56. 1909.

"Troubles of this nature are becoming serious in California. No evidence is present of any parasitic attack."

82. SMITH, R. E., AND SMITH, E. H. California Plant Diseases. California Agr. Exp. Sta., Berkeley. Bull. 218, pp. 1092 and 1093. June, 1911.

Fruit spot of apple is described and illustrated, and is said to be similar to "brown spot" or "Baldwin spot." "No cause or remedy satisfactorily demonstrated in California." "Hollow Apple" or Crinkle is also figured.

83. SORAUER, P. Schutz der Obstbäume gegen Krankheiten—das Stippigwerden der Aepfel, p. 80. Stuttgart, 1900.

Cavities occur in the diseased tissue produced by the rupturing of the cells during the process of swelling, and this, taken in conjunction with the presence of starch, while it is absent from the surrounding healthy tissue, shows that the disease began before maturity was reached.

84. ——— "Stippigwerden" der Aepfel. *Atlas der Pflanzenkrankheiten*, Plate XXXIV. Berlin.

The disease was supposed to be of a parasitic nature, but the parasite unknown.

85. ——— Die Stippflecke. *Handbuch der Pflanzenkrankheiten*, p. 166. 1909.

Most common in loose soils in dry seasons and the firm-fleshed varieties least susceptible. Owing to premature dryness of the soil the necessary quantity of organic material is prevented from reaching the developing fruit, so that certain groups of cells are starved and quickly perish.

86. SORAUER, P., AND HOLLRUNG, M. Stippigfleckigkeit der Aepfel. *Zwölfter Jahresbericht des Sonderausschusses für Pflanzenschutz*, p. 133. 1902.

The distribution of the disease in various districts of Germany is given, and the injury is said to be greater than that caused by Fusicladium.

87. SOUTHERN GROWER. Bitter Pit or Fruit Spot. *Gardeners' Chronicle*, L., p. 353. November 18, 1911.

States that apples affected with "Bitter Pit" were noticed at the recent fruit show of the Royal Horticultural Society in several of the prize lots.

88. STEWART, F. C. Notes on various Plant Diseases—Baldwin Fruit Spot. New York State Sta. Bull. 164. 1899.

Not caused by fungi or bacteria, and real cause unknown.

89. ——— Is the Baldwin Fruit Spot caused by Fungi or Bacteria? New York Agricultural Experiment Station, Geneva. Bull. 164, p. 215. December, 1899.

"Microscopic examination of the affected tissue revealed no fungus hyphæ and no bacteria which could be definitely demonstrated as such."

90. STEWART, F. C.; ROLFS, F. M.; AND HALL, T. H.—Fruit Spot. New York Agricultural Experiment Station, Geneva. Bull. 191. December, 1900.

Varieties specially liable to the disease are—Baldwin, Northern Spy, and Rhode Island Greening. The general opinion is expressed that large specimens are more affected than small ones of the same variety.

91. STEWART, F. C. Plant Diseases—Apple. New York Agr. Exp. Sta. Twenty-sixth Annual Report, p. 123. 1908.

Neither fungi nor bacteria are concerned in this trouble.

92. TASCHENBERG, E. L. *Schutz der Obstbäume*—Das Stippichwerden der Aepfel, p. 112. Stuttgart, 1879.

He refers to Jaeger, who in 1869 considered the cause of Bitter Pit to be bringing early maturing fruit too soon into the cellar, whereas it should be kept for a considerable time in a dry room.

93. TIDSWELL, F. (AND OTHERS). Report of the Government Bureau of Microbiology for 1909, p. 53. Government Printer, Sydney, 1910.

"Bitter Pit also received considerable attention, but no causative organism could be found."

94. WHETZEL, H. H. Baldwin Spot or Stippin. Proceedings, New York Fruit-growers' Association, January, 1912.

A summary is given of the leading features of this disease, and under the heading of control it is stated—"It is thus evident that those practices which most tend to a uniform normal growth throughout the season, with fewest sudden stimulations or checks on growth, are most apt to afford least losses year in and year out from the Stippin or Baldwin Fruit Pit."

95. WHITE, JEAN. Bitter Pit in Apples. Proceedings, Royal Society, Victoria, XXIV. (N.S.), Pt. I. 1911.

"The results of my observations, and of the experiments performed, without one single exception so far, seem to indicate that the complaint popularly known as Bitter Pit is, strictly speaking, not a disease at all, but rather a symptom of slow local poisoning, and that in the cases actually examined so far it appears to be due to the poisonous compounds sprayed on to the surface of the fruits for the eradication of pests, more especially insect pests."

96. ——— Bitter Pit and the Enzymes of the Apple. *Journal, Department of Agriculture*, Victoria, VIII., p. 805. 1910.

The investigation was not fully completed, but the somewhat imperfect data seemed to show that the enzymes persisted in the diseased cells for a short time after the death of the cells.

97. WORTMANN, J. Ueber die sogen. "Stippen" der Aepfel. *Landw. Jahrb.*, XXI., p. 663. 1892.

The theory brought forward as to its cause is, that concentration of the sap, following the loss of water by transpiration, occurs in the pulp cells adjoining the vessels, and the acidity of the concentrated sap is the direct cause of the injury.

98. ZSCHOKKE, A. Stippigwerden der Aepfel. *Landw. Jahrb. d. Schweiz*, II., p. 192. 1897.

Agrees with Wortmann that the disease is directly or indirectly related to the transpiration, and considers that the unequal conduction of water in the fruit-flesh is one of the most important factors.

GENERAL LITERATURE.

99. Beach, S. A., and Clark, V. A. New York Apples in Storage. New York Agricultural Experiment Station, Geneva. Bull. 248. March, 1904.

100. Bigelow, W. D., Gore, H. C., and Howard, B. J. Studies on Apples. U.S. Department of Agriculture, Bureau of Chemistry. Bull. 94. 1905.

101. Brooks, C., and Black, C. A. Apple Fruit Spot and Quince Blotch. *Phytopathology*, II., p. 63. April, 1912.

102. Browne, C. A. A Chemical study of the Apple and its Products. Department of Agriculture, Pennsylvania. Bull. 58. 1897.

103. Bunyard, G. *Apples and Pears*, p. 4. Jack, London. 1911.

104. Cameron, F. K. *The Soil Solution, The Nutrient Medium for Plant Growth.* Williams and Norgate, London. 1911.

105. Eustace, H. J. Investigations of some Fruit Diseases. New York Agricultural Experiment Station, Geneva. Bull. 297. February, 1908.

106. Gore, H. C. Studies on Fruit Respiration. U.S. Department of Agriculture, Bureau of Chemistry. Bull. 142. 1911.

107. Hooper, C. H. A Year among the Orchards of Nova Scotia. *Journal, Royal Horticultural Society*, London, XXIII., Pt. 1. 1899.

108. Lindet, L. Sur l'oxydation du tannin de la pomme à cidre. *Le Cidre*, p. 150. 1893.

109. Malfatti, J. Beiträge zur Anatomie der Birn-und Apfel-frucht. *Zeitschr. Nahr.-Unters. Hyg.*, X., p. 265. 1896.

110. Massee, G. The "Spot" Disease of Orchids. *Annals of Botany*, IX., No. 35, p. 421. 1895.

111. McAlpine, D. The Fibro-vascular System of the Apple (Pome) and its Functions. Proceedings Linnean Society, New South Wales, XXXVI., Pt. 4. 1912.

112. ——— The Fibro-vascular System of the Pear (Pome). Proceedings Linnean Society, New South Wales. Ibid. 1912.

113. Morse, F. W. The Respiration of Apples and its relation to their keeping. New Hampshire Sta. Bull. 135. 1908.

114. Munson, L. S., Tolman, L. M., and Howard, B. J. Fruits and Fruit Products: Chemical and Microscopical Examination. U.S. Department of Agriculture, Bureau of Chemistry. Bull. 66 (revised). 1905.

115. Pfeffer, W. *The Physiology of Plants.* Translated and Edited by Professor A. J. Ewart. Vols. I.–III. Oxford. 1900–1906.

116. Pick, H. Ueber die Bedeutung des rothen Farbstoffes bei den Phanerogamen und die Beziehungen desselben zur Stärkewanderung. Bot. Centralblatt, XVI., No. 9, p. 281. 1883.

117. Rane, F. W., Lamson, H. H., and Morse, F. W. The Cold Storage of Apples. New Hampshire Sta. Bull. 93. 1902.

118. Sorauer, P. *Physiology of Plants.* English edition, London. 1895.

119. Varcollier, G. Cause of the Presence of Abnormal Quantities of Starchi n Bruised Apples. Compt. Rend. Acad. Sci. 141, No. 8, p. 405. 1905.

120. Woods, A. F. Stigmonose: a Disease of Carnations and other Pinks. U.S. Department of Agriculture, Division of Vegetable Physiology and Pathology. Bull. 19. 1900.

IV.—CHARACTERISTICS OF BITTER PIT.

(Figs. 1–29.)

FRONTISPIECE.

Reproductions by the three-colour process direct from the fruit of Lord Wolseley and Cox's Orange Pippin—

(*a*) Lord Wolseley, about one-third ripe, showing surface pits or depressions and a median longitudinal section clearly indicating the brown patches just beneath the green skin.

(*b*) Cox's Orange Pippin, fully grown, showing surface depressions and a thin oblique slice removed to show internal brown spots.

PLATE I.

Fig.

1. Esopus Spitzenberg, with depressed surface markings of Bitter Pit. (Nagambie, 7.3.11.)

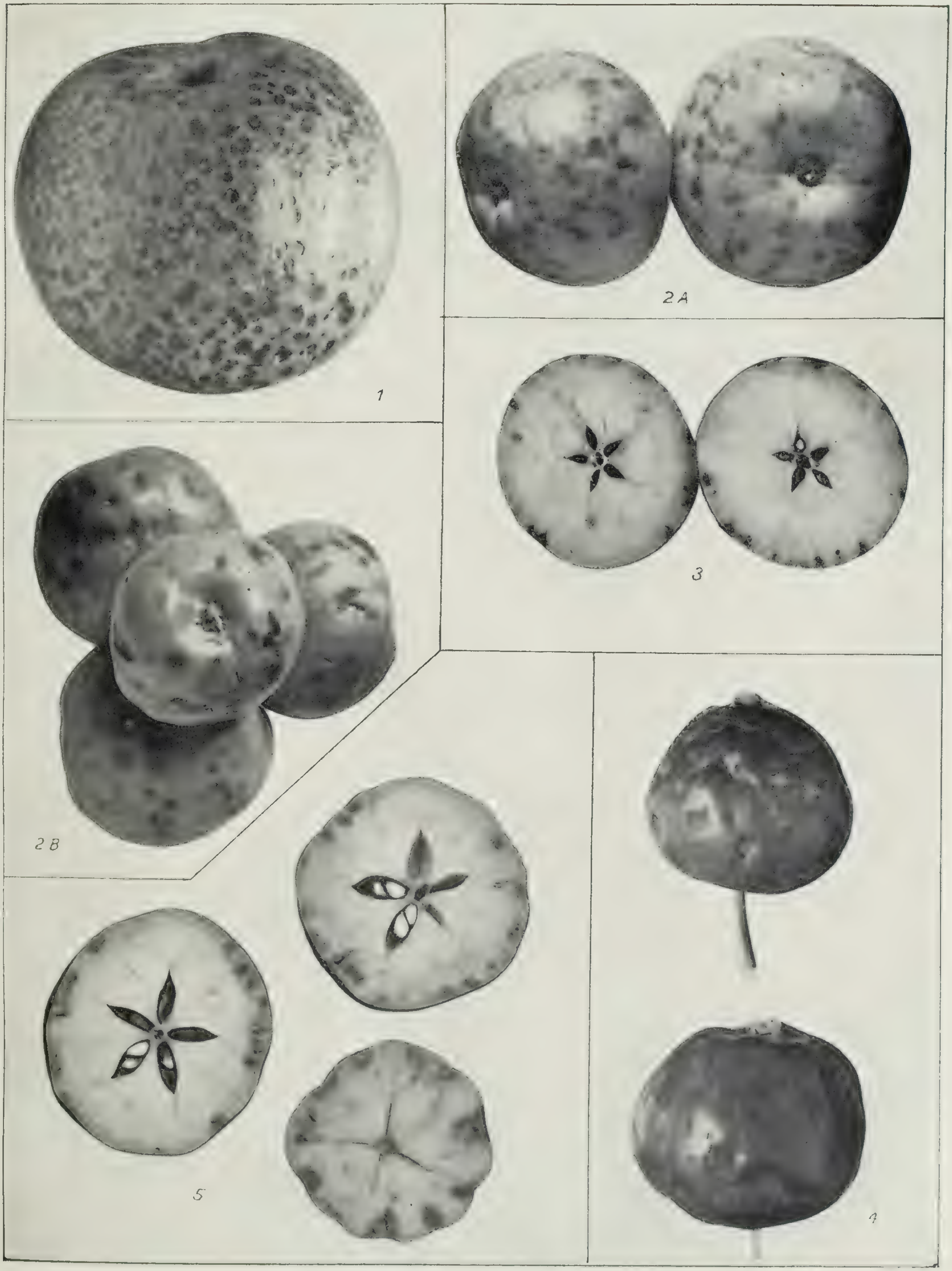
2*a*. Annie Elizabeth, with depressed surface markings of Bitter Pit. (Burnley, 5.3.09.)

2*b*. Annie Elizabeth, with depressed surface markings of Bitter Pit.

3. Cross section of same, showing brown patches just beneath the skin.

4. Calville Blanche Été, with Bitter Pit. (Burnley, 14.12.11.)

5. Cross section of same.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2B
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PLATE II.

(Figs. 7–10 from photographs by F. A. Joyner.)

Fig.

6. Munroe's Favourite or Dunn's Seedling badly pitted, from young trees, although this variety is generally free. (Clarendon, South Australia, 2.4.12.)
7. Dumelow's Seedling, with Bitter Pit. (Bridgewater, South Australia, 3.5.12.)
8. Cross section of same, showing brown patches just beneath the skin.
9. Cleopatra or New York Pippin with Bitter Pit. (Bridgewater, South Australia.)
10. Cross section of same, showing "mouldy core," in addition to Bitter Pit.
11. Jonathan Apple, imported from California, showing Bitter Pit.

PLATE II.

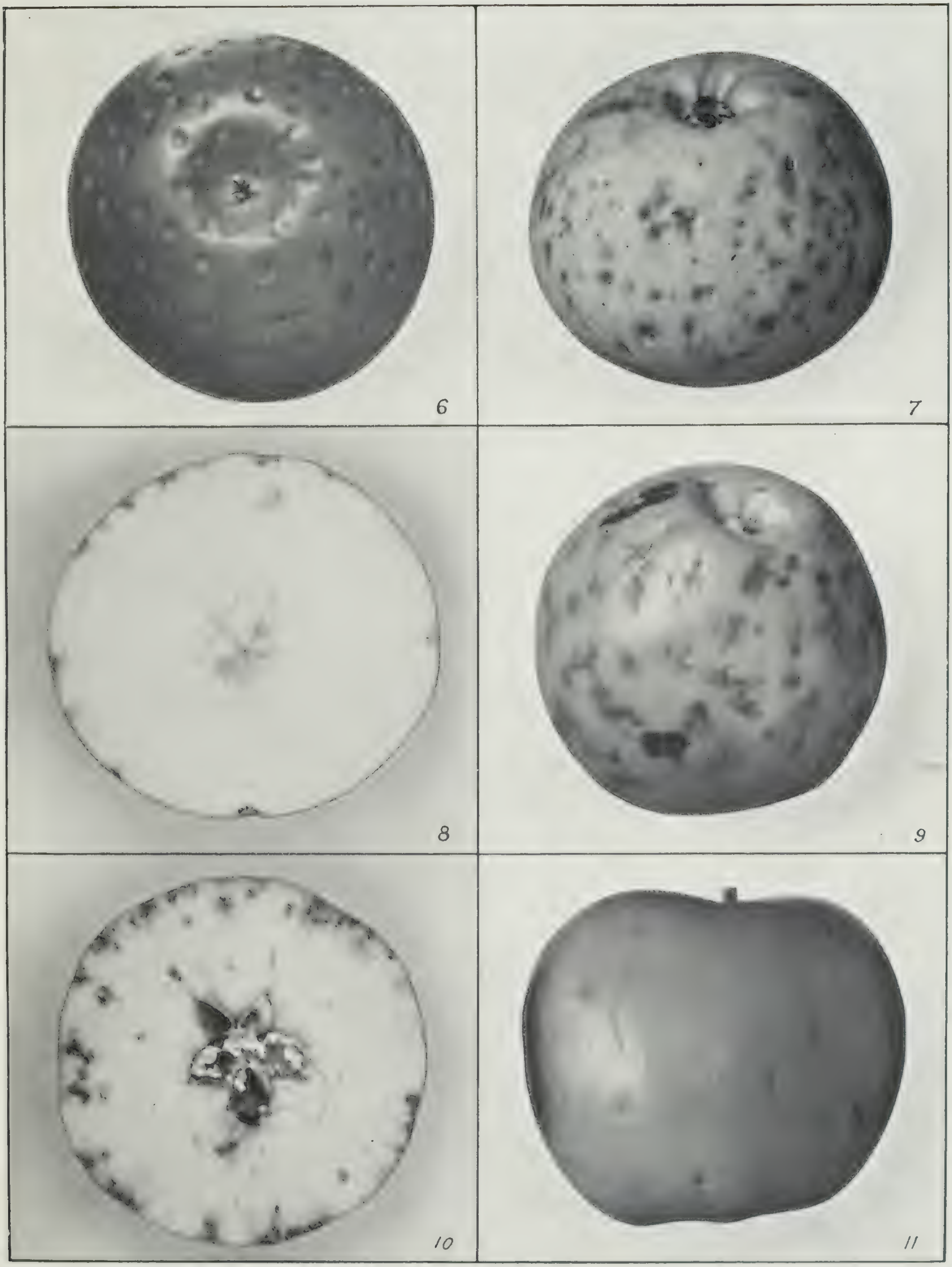

PLATE III.

Fig.

12. Josephine Pear with Bitter Pit. (Campbell's Creek, 20.4.11.)
13. Cross section of same through core, showing brown tissue through flesh.
14. Section lengthwise of similar Pear.
15. Winter Nelis Pear with Bitter Pit. (Campbell's Creek, 20.4.11.)
16. Cross section of same.
17. Section lengthwise of similar Pear.

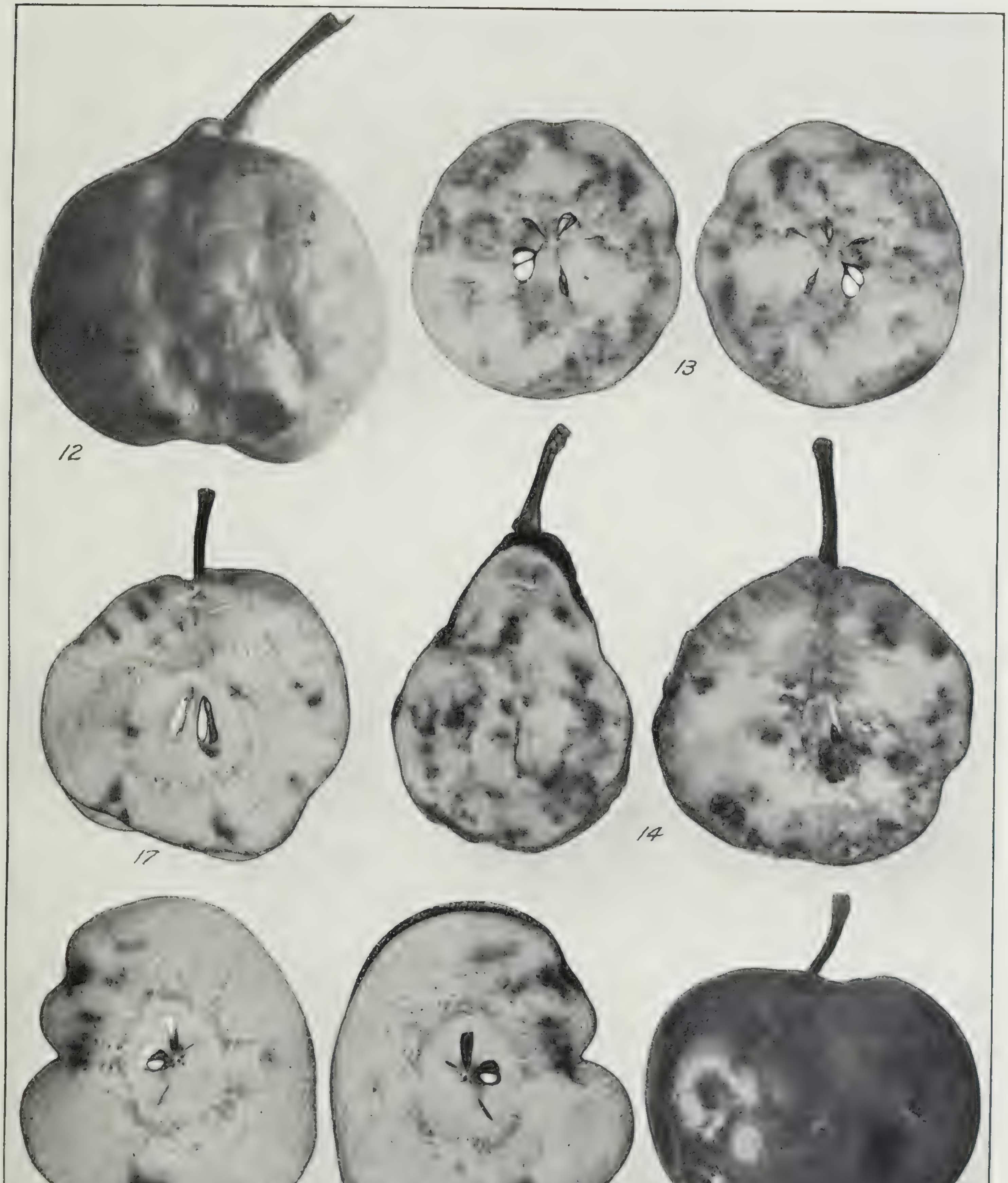
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PLATE IV.

Fig.

18. Williams' Bon Chrêtien Pear (Winter Bartlett) with Bitter Pit. Surface raised into irregular folds and puckered, forming rounded elevations with corresponding depressions. (Belair, South Australia, 3.4.12.)
19. Section lengthwise of same, showing brown patches beneath the skin opposite depressions.
20. Cluster of Beurré Clairgeau Pears, about one-third grown, with smallest pear in centre, which is not usual.


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PLATE V.

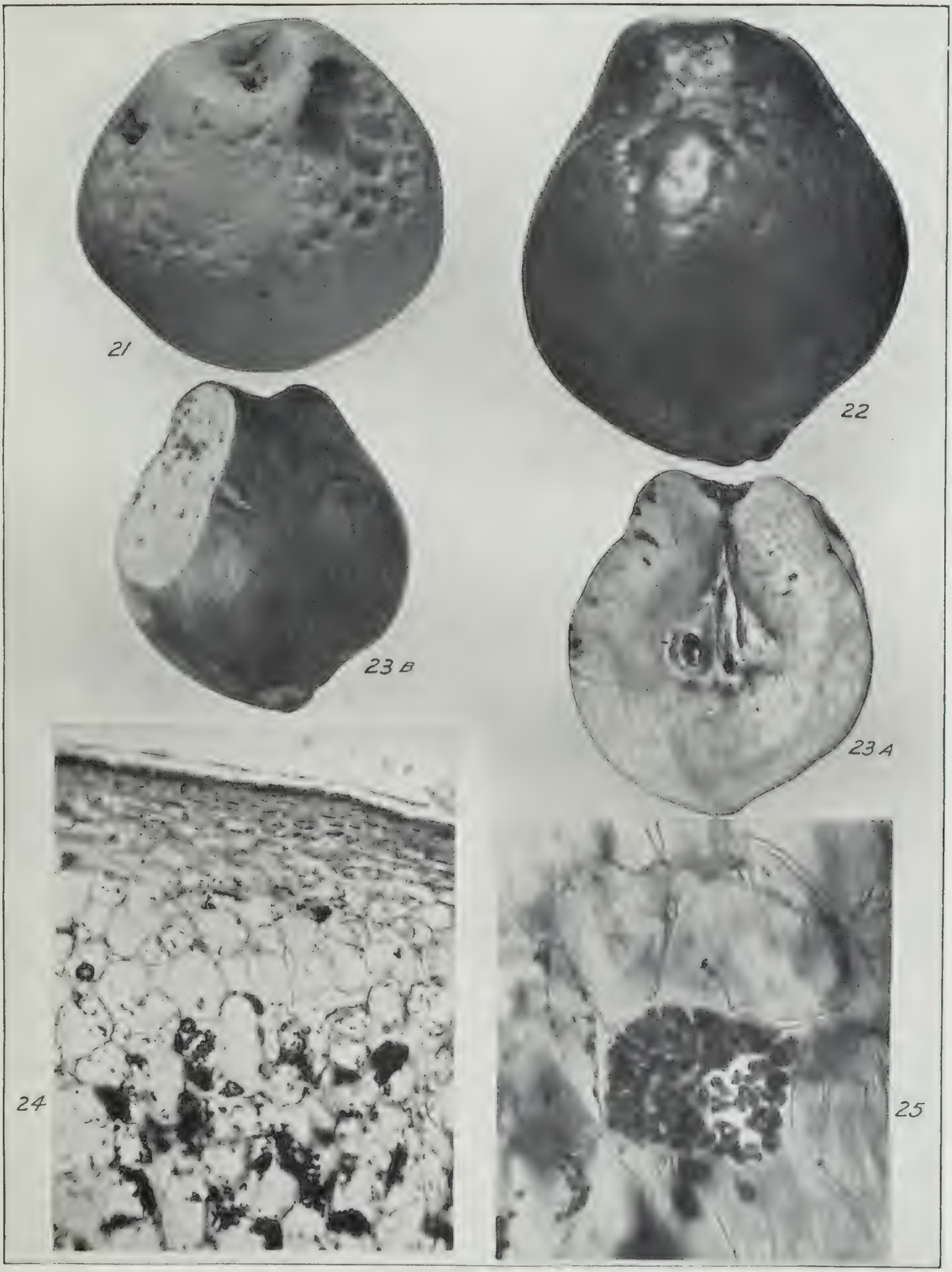
Fig.

21. Quince with Bitter Pit. (A. Strong, Donnybrook, Western Australia, 1911.)
22. Quince with Bitter Pit. (Near Angaston, South Australia, 2.4.12.)

23*a*. Section lengthwise of same, showing brown patches beneath skin.

23*b*. Oblique section of same.

24. Cross section through Bitter Pit spot of Rymer Apple, which was unsprayed. (Glen Huntly) .. .. × 125
25. Portion of same further enlarged, showing cell with starch-grains stained × 250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23 B
23 A
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PLATE VI.

Fig.

26*a*. Section through brown patch of Calville Blanche Été, showing two vascular bundles in lower half .. .. × 50

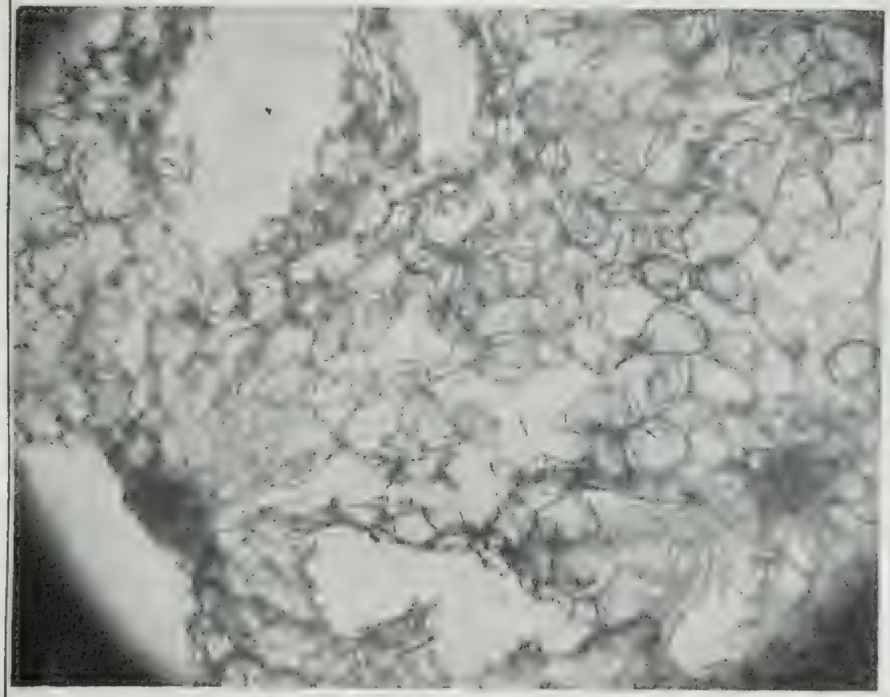
26*b*. Portion of same section, showing diseased cells collapsed and leaving large spaces .. .. × 50

27. Section through brown patch of Red Astrachan Apple with adjoining healthy tissue .. .. × 25

28. Section from same patch, mounted at once in glycerine and water and photographed, showing the cells collapsed and large cavities scattered through the section .. .. × 170

29. Section from same patch in sequence, placed in water for forty hours and then photographed. The collapsed cells have absorbed moisture and become distended .. .. × 170

26 A



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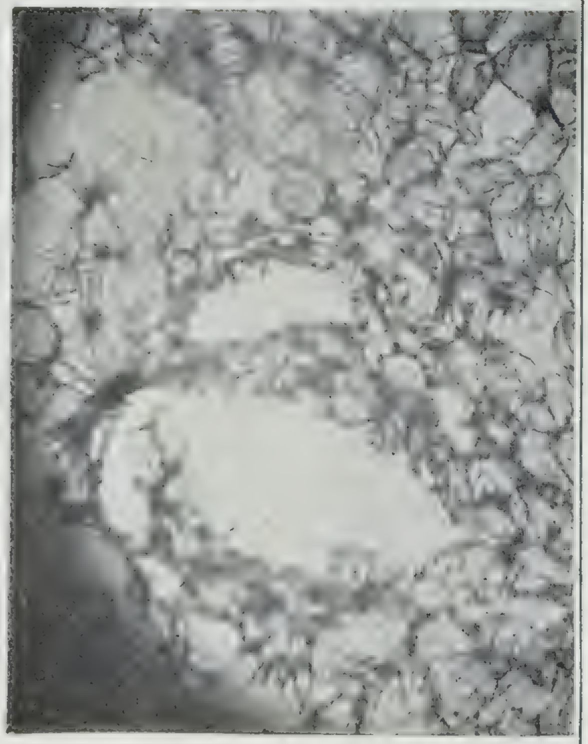

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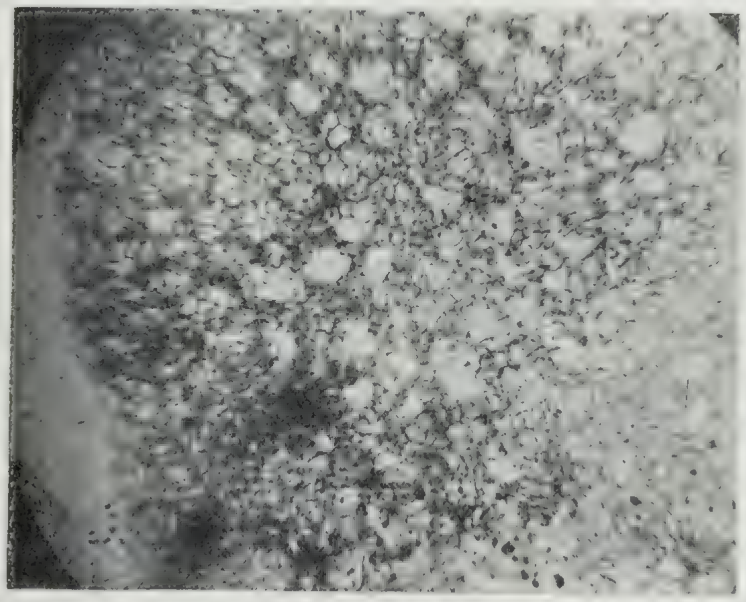

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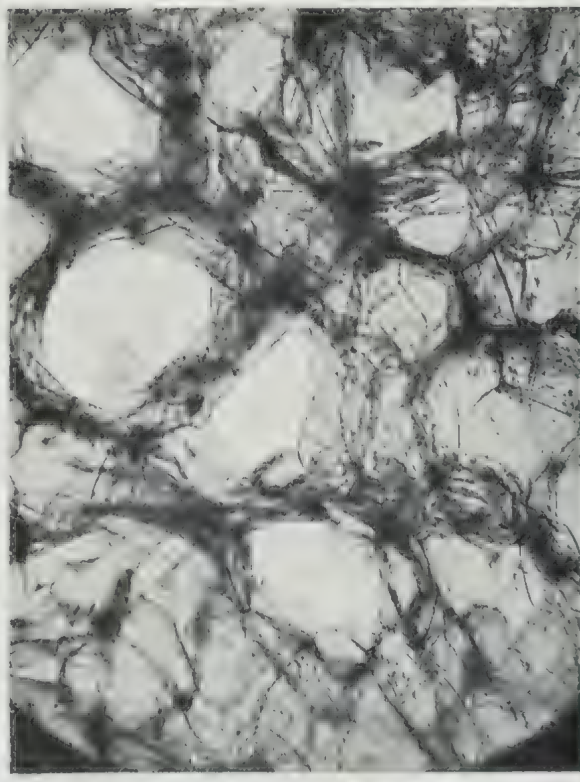

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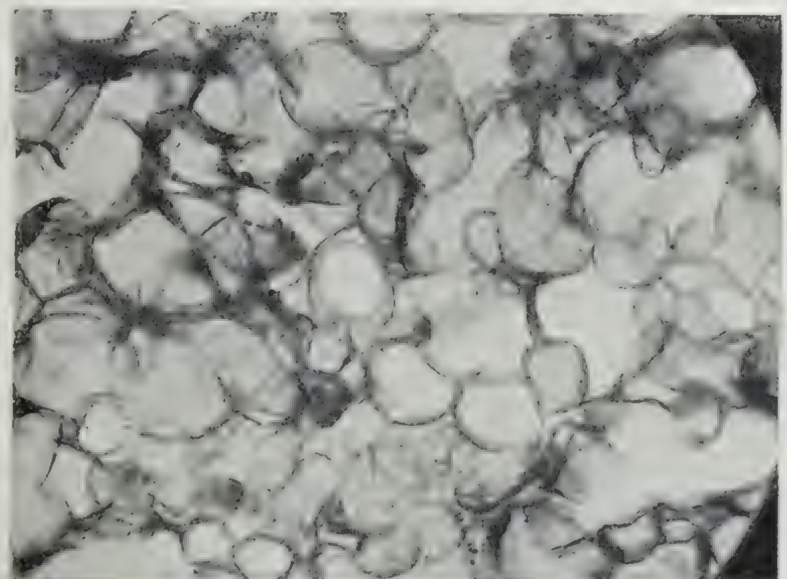

V.—CONFLUENT BITTER PIT OR CRINKLE.

(Figs. 30–44.)

PLATE VII.

(Figs. 32–41 from photographs by F. A. Joyner.)

Fig.

30. Newton Wonder, showing Crinkle or Confluent Bitter Pit at crown end, one-third grown. (Box Hill, 5.2.12.)
31. Cross section of same towards crown end.
32. Rome Beauty, showing deep indentation on one side due to "Crinkle." (Bridgewater, South Australia, 3.5.12.)
33. Cross section of same, showing brown tissue with deep cavities immediately beneath skin, which is still intact. The long dark marking extending from the skin to the core is a gutter in the healthy tissue, caused when making a section of the apple.
34. Rome Beauty, showing Crinkle in profile.
35. Five Crown or London Pippin, front view of Crinkle.
36. Cross section through same, showing the skin thrown into folds but still intact.
37. Rome Beauty with Crinkle round the crown.


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PLATE VIII.

Fig.

38. Cross section of same through crown.
39. Munroe's Favourite or Dunn's Seedling with circular "Crinkle" around and just below the crown.
40. Cross section of same through base of "Crinkle."
41. Cross section of same immediately beneath crown, showing numerous large cavities in the flesh.
42. Annie Elizabeth Apple grown inside calico bag on tree, showing Bitter Pit and "Crinkle" combined. (Burnley, 6.3.12.)
43. Cross section of same, showing Bitter Pit spots and Crinkle.
44. Five Crown—Cross section about middle, showing "Crinkle" and water-core combined .. .. slightly enlarged


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VI.—AN "OBSCURE DISEASE" OF THE APPLE.

(Figs. 45–49.)

PLATE IX.

Fig.

45. Malformed and stunted Apples of Pomme de Neige variety. (Orange, New South Wales, 20.2.12) .. .. reduced

Fig. 45

PLATE X.

Fig.

46. Sections of same, showing brown patches extending even to the core .. reduced
47. Sections of Pomme de Neige when the Apples were about the size of walnuts, and showing the earliest Bitter Pit of the season. (Orange, December, 1911.)
48. Pomme de Neige of normal size with Bitter Pit. (Burwood, 30.4.12.)
49. Cross section of same, showing brown patches beneath skin and scattered through flesh.

VII.—EFFECTS OF FROST ON THE APPLE.

(Fig. 50.)

50. Rymer Apples, showing the effects of frost in rendering them distorted and one-sided, so that the "eye," instead of being at the apex, is at one side. (Harcourt, 18.3.12.)


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VIII.—"WOOLLY STRIPE" OF SEED-VESSELS AND A SIMILAR DEVELOPMENT FROM THE RUPTURED FLESH OF THE APPLE.

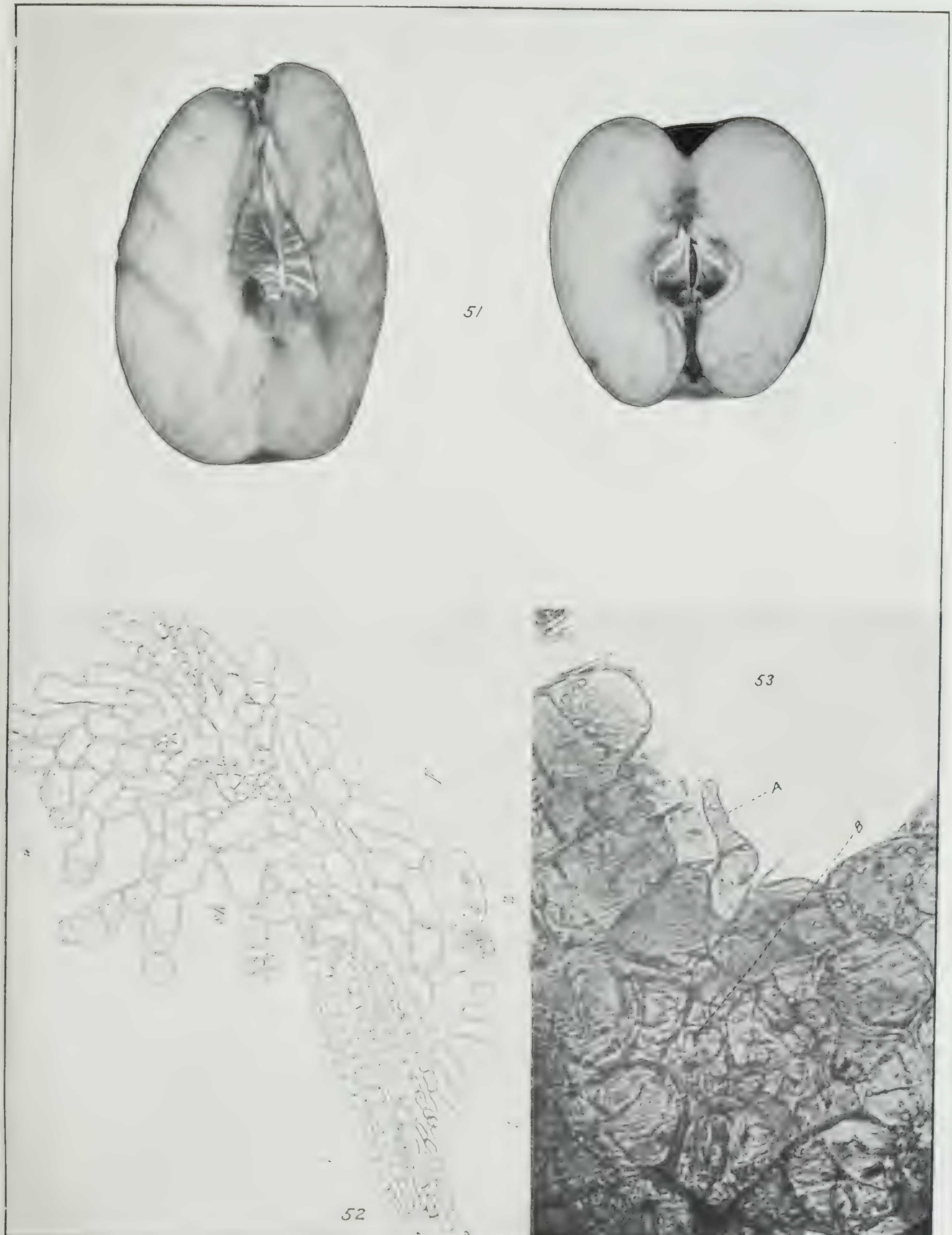
(Figs. 51–53.)

PLATE XI.

Fig.

51. Section lengthwise of Cleopatra Apples, showing "Woolly Stripe" on inner surface of cartilaginous wall of seed-vessels.
52. Section through cartilaginous wall of seed-vessels, showing the woolly hair-like structures bursting through the ruptured wall (After Sorauer) .. magnified
53. Cell of flesh adjoining ruptured tissue, giving rise to a filamentous jointed structure (*a*) containing starch, and the tissue beneath, showing the same hypha-like structures ramifying through it (*b*).

PLATE XI.



IX.—APPEARANCES MISTAKEN FOR BITTER PIT.

(Figs. 54–61.)

PLATE XII.

Fig.

54. Cleopatra Apple with hail-marks on one side. (Tamar Valley, Tasmania, 18.1.12.)
55. Royal Oak Apple with hail-marks. (Burnley, 30.10.11.)
56. Cluster of Tuft's Baldwin Apple with hail-marks. (Burnley, 30.10.12.)

57*a*. Jonathan Apple with spotting due to citric acid—pricked. The punctures are plainly visible on right-hand side of Figure.

57*b*. Jonathan Apple with spotting due to citric acid—unpricked.

58. Mature Yates Apple, showing effect on skin when rubbed with a saturated solution in alcohol of corrosive sublimate.
59. Solitary Jonathan Apple from tree which had been covered with mosquito netting and wire-netted over that. It had every external appearance of "Pit," but the depressions on the skin were due to a Looper caterpillar tunnelling beneath. (Burnley, 6.3.12.)
60. Five Crown or London Pippin with brown depressions on surface due to Bacteria.
61. Cross section of same through depressions, showing that the pitting is entirely superficial.

PLATE XII.

X.—DISEASES ASSOCIATED WITH BITTER PIT.

(Figs. 62–68.)

PLATE XIII.

Fig.

62. Black Spot or "Scab" on White Transparent Apple when about size of hazel nut. This was mistaken for Bitter Pit, but it is also found associated with it. (Burnley, 30.10.11.)

63. Bitter Pit and "Bitter Rot" combined on Lord Wolseley. (Bacchus Marsh, 30.6.11.)

64. Bitter Pit and "Bitter Rot" combined. (Burnley, 28.7.11.)

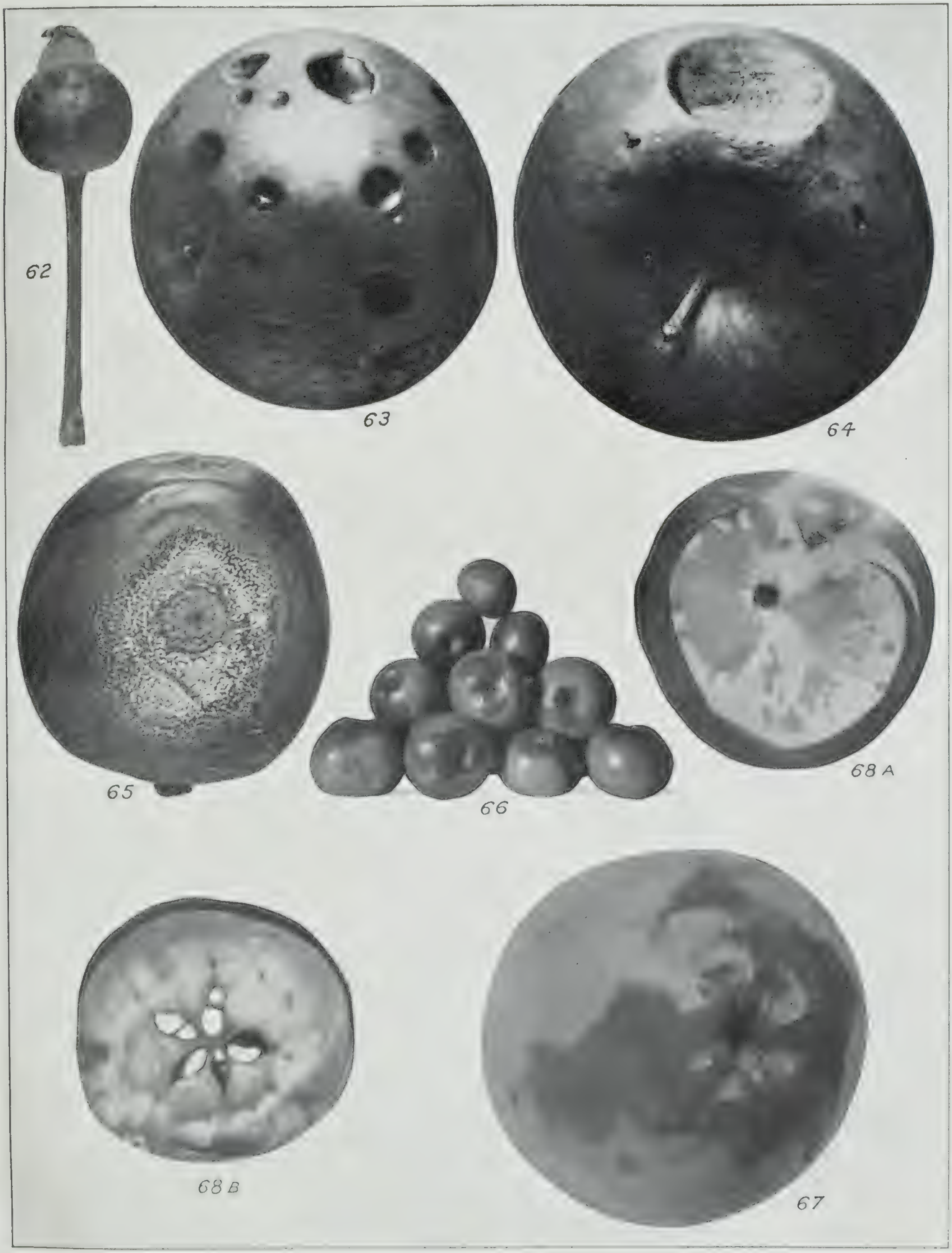
65. Bitter Rot well developed in Early Red Margaret.

66. Group of Stone Pippin Apples, showing "Glassiness" or "Water-core."

67. Lord Wolseley, showing "Glassiness" at eye end. (Burnley, 23.4.11.)

68*a*. Red Must, a Cider Apple, half-grown, showing "Glassiness" or "Water-core" and Bitter Pit combined—Section near crown end.

68*b*. Cross section of same about middle.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68 A
68 B
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XII.—GENERAL STRUCTURE OF THE APPLE AND PEAR.

(Figs. 69–82.)

PLATE XIV.

Fig.

69. Section lengthwise of Apple, showing the wall of the "Core" attached below to the top of the stalk, and above, passing into the "Eye."

70. Thin slice from longitudinal section, showing scattered portions of vascular bundles and the forked branches beneath the skin.

71. Section crosswise of Rome Beauty Apple, showing the ten primary fibro-vascular bundles in the form of ten greenish dots arranged in a circle, each bundle being either opposite to or intermediate with each of the five carpels.

72. Thin slice of transverse section, showing abnormal form with six seed-vessels and twelve main vascular bundles corresponding.

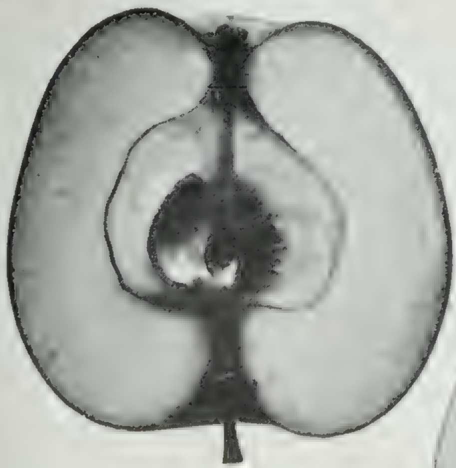
73. Cross section, showing four seed-vessels and eight main vascular bundles corresponding.

74. Sections crosswise about middle of very young Cleopatra, showing ten distinct vascular bundles surrounding the "Core" which forms the bulk of the section. (Burnley, 25.9.11) .. .. × 3

75. One of the same sections enlarged .. .. × 30

76. Section lengthwise of young Cleopatra further advanced, showing the increase in the fleshy portion, along with the enlargement of the core .. .. × 3

77. Section crosswise of same, showing distinct core and ten main vascular bundles opposite and intermediate to seed-vessels.



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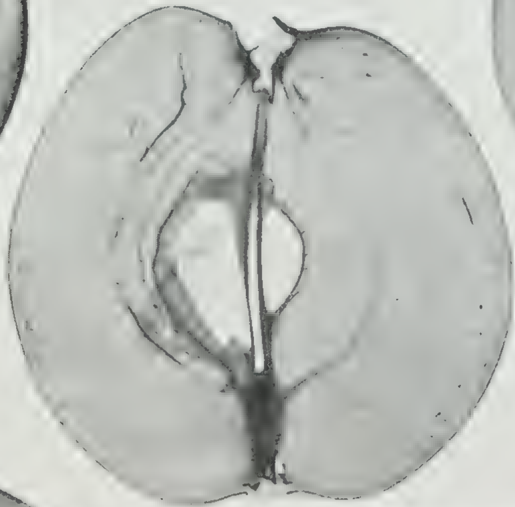

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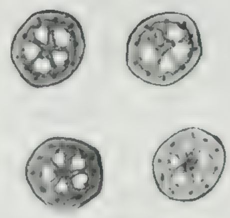

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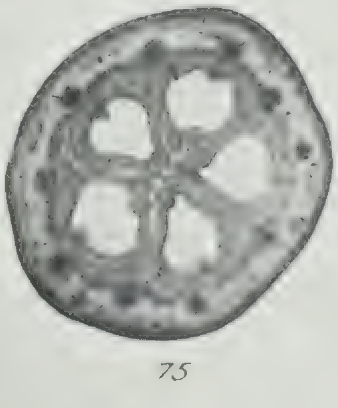

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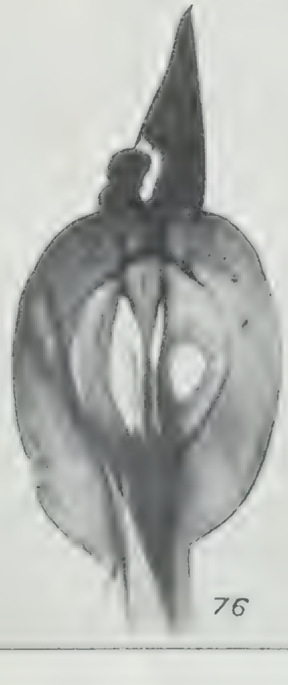

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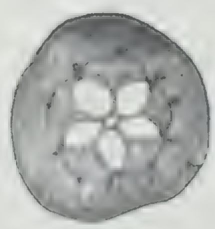

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PLATE XV.

Fig.

78. Section lengthwise of mature Pear, showing the "Core" towards the crown end, the strands of vascular bundles in the fleshy portion, and the "Stone-cells" dotting the flesh .. .. slightly reduced
79. Section crosswise of mature Pear through seed-vessels, showing "Stone-cells" densely surrounding "Core" as well as scattered through flesh.
80. Section crosswise of mature Pear, similar to preceding, but only showing the central "Core," with two bundles alongside of each other between the seed-vessels. The pair of bundles adjoining the inner face of each seed-vessel represent the forking branch from each of the five intermediate main bundles .. × 2
81. Section lengthwise of young Pear, showing the elongated fleshy portion below the seed-vessels.
82. Section crosswise through seed-vessels, showing numerous stone-cells.

XIII.—FIBRO-VASCULAR SYSTEM OF SKELETON AND VESSELS OF APPLE AND PEAR.

(Figs. 83–100.)

Fig.

83. Vascular system of Pear as seen when flesh is removed.
84. Vascular system of same spread out so as to expose the "Core."
85. Three main bundles shown supplying individual seed-vessels. The primary bundles opposite to the seed-vessels branch inwardly, and supply the dorsal or outer face, while those intermediate supply the ventral or inner face. Each vascular bundle also branches outwardly, forming a net-work with plume-like branchlets given off from each mesh of the net to the periphery.

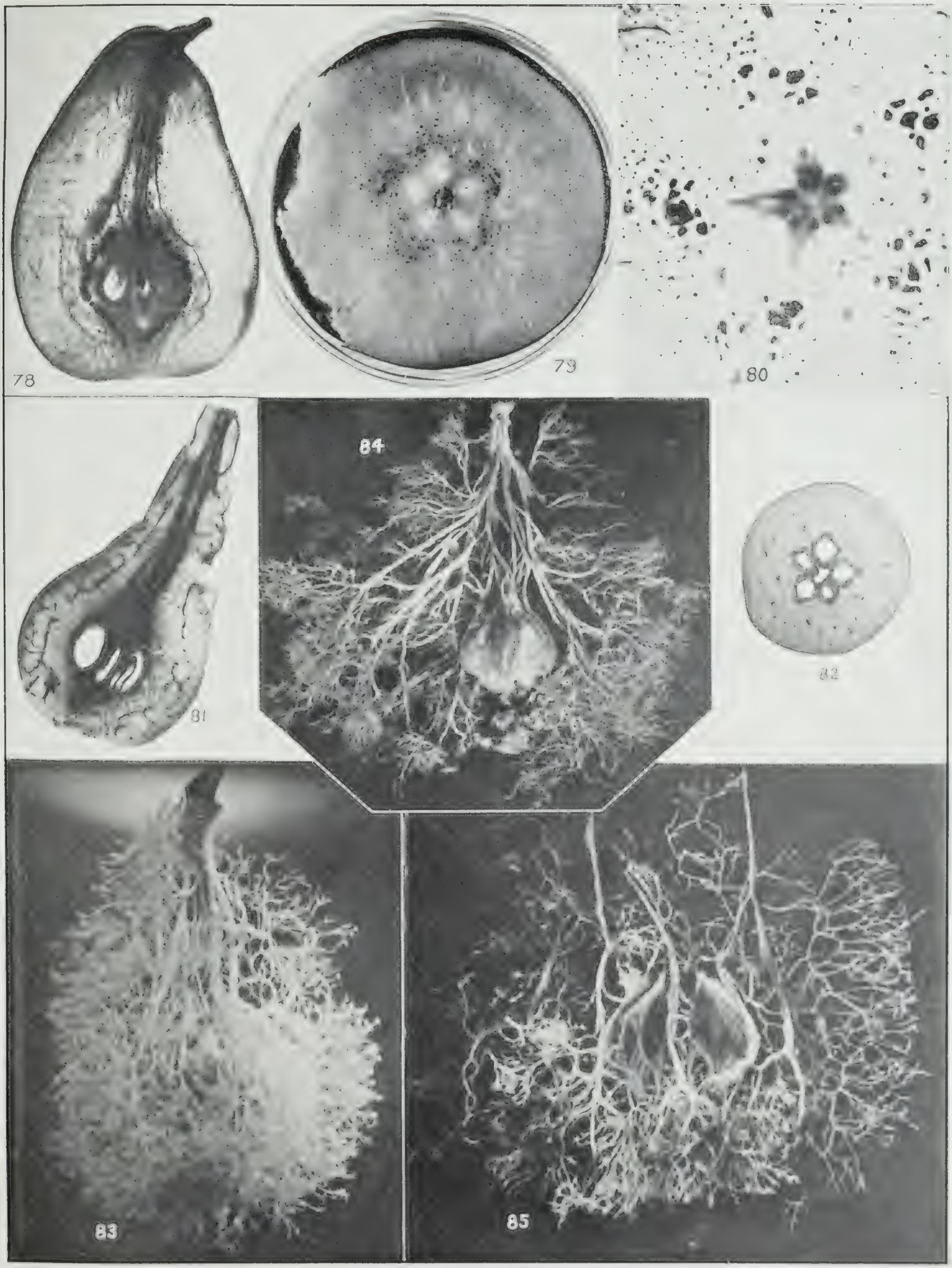
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PLATE XVI.

Fig.

86. Vascular net-work of Achan Pear, a short distance beneath the skin, enveloping the flesh.

87. Cross section of fruit-stalk of Pear just as it enters fruit, showing ten fibro-vascular bundles. The stalk was somewhat shrunken, and the section shows the woody tissue ruptured in nine of the ten bundles.. .. .. .. × 30

88. Vascular system of Apple with branches from main bundles spread out.

89. Top of stalk of Yates Apple, where the vascular bundles diverge, showing ten main strands radiating from it.

90. Vascular net-work of Apple with Bitter Pit patches attached. The net-work is interrupted where the tough brown patches occur.

91 Oblique view of same, showing plume-like branches standing out from net-work.

92 Portion of "Glassy" Apple (Prince of the Pippins) with skin removed, showing vascular net-work The net is not interfered with in this disease, and can be seen through the transparent "Glassy" tissue.

93 Very young Cleopatra with vascular net, showing that it exists from the earliest stages of the fruit .. .. × 3

94 Section lengthwise of Apple, showing vascular net distributed over seed-vessels and branches from main bundles spreading towards circumference to form network.

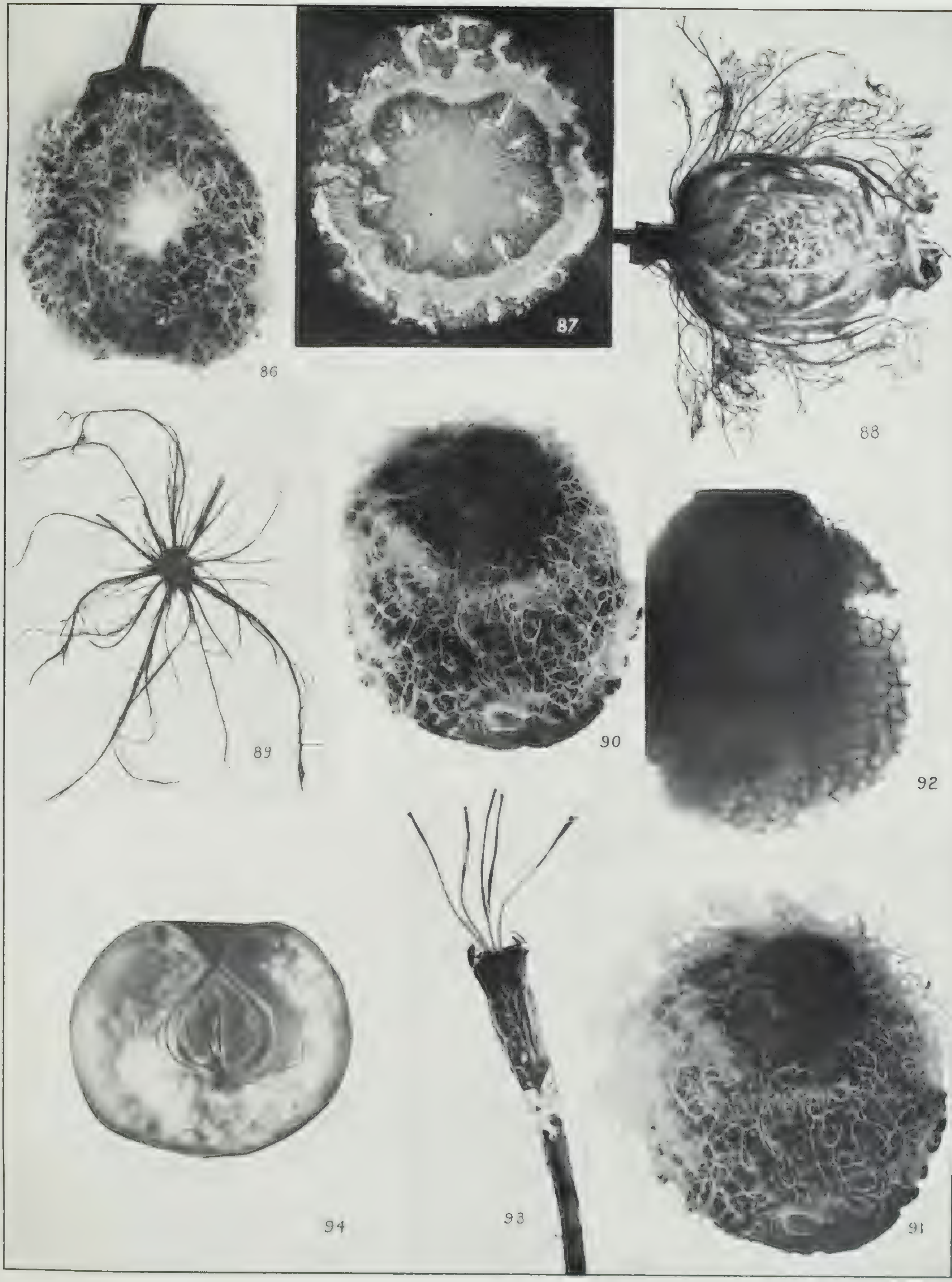
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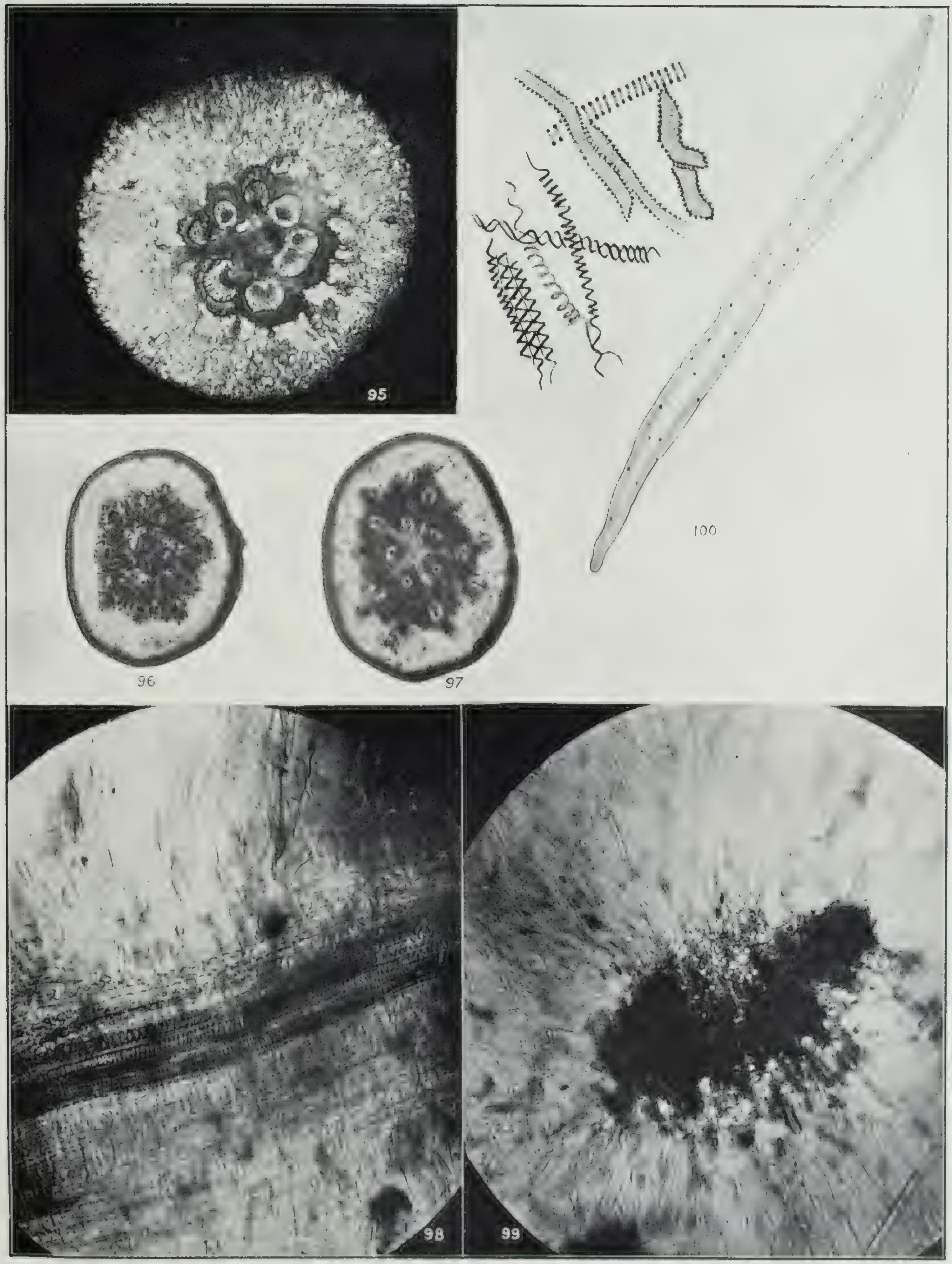
PLATE XVII.

Fig.

95. Cross section of fruit-stalk of Apple just as it enters fruit, showing ten fibro-vascular bundles—four single, and the other six forming three pairs on left side.
96. Cross section of stalk of young Cleopatra Apple, showing the ten main vascular bundles .. .. × 30
97. Cross section of young Cleopatra Apple below seed-vessels, also showing ten bundles—five opposite to, and five between position of seed-vessels × 30
98. Section lengthwise of a vascular bundle, showing the spiral vessels prominently .. .. × 100
99. Section crosswise of vascular bundle, showing xylem or wood portion (upper) and phloem or bast portion (lower) .. .. .. × 100
100. Elements of fibro-vascular bundle of Apple (after Howard) .. .. × 425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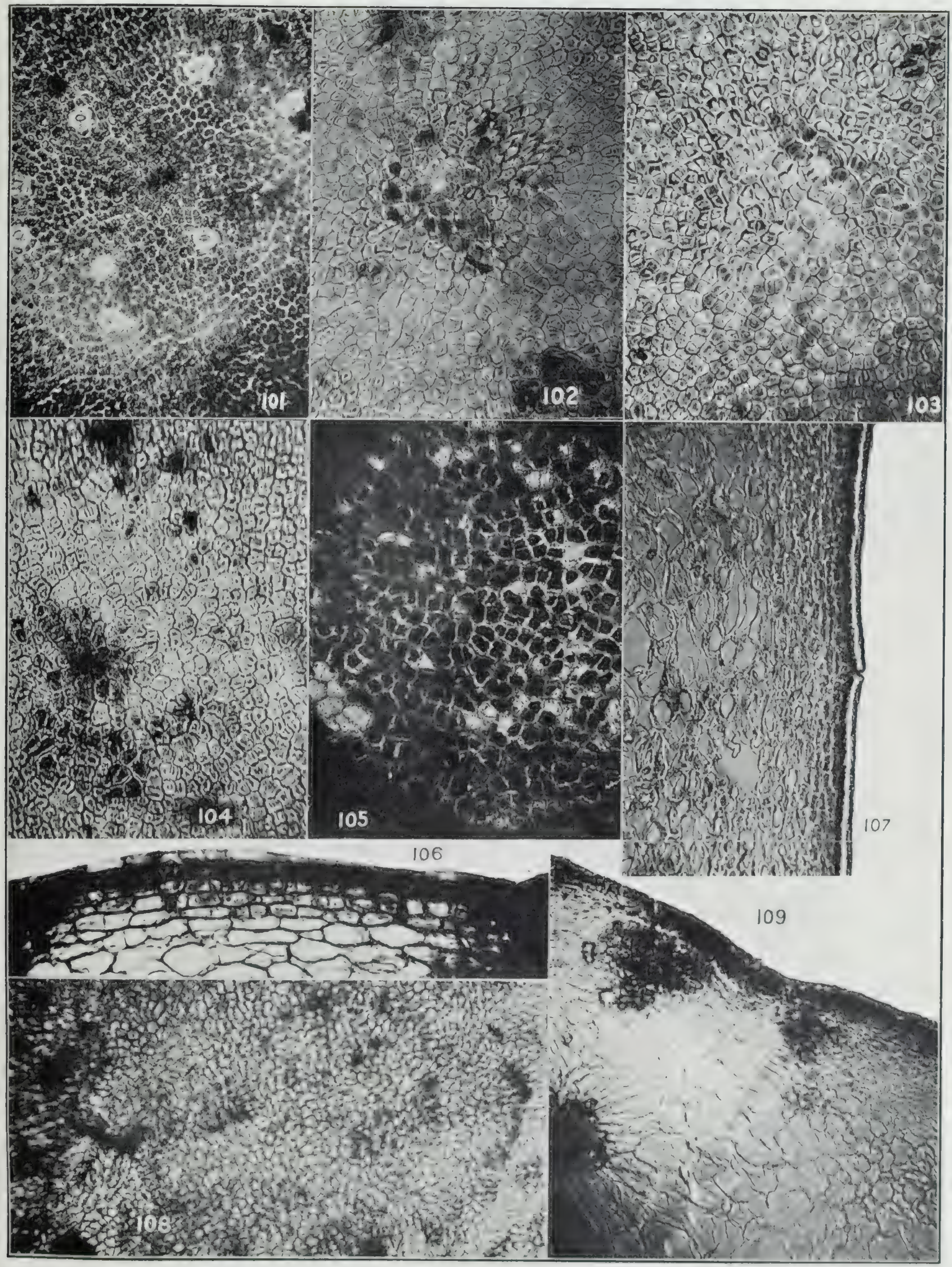
XIV.—THE SKIN OF THE APPLE AND PEAR.

(Figs. 101–109.)

PLATE XVIII.

Fig.

101. Stomata in skin of young Cleopatra Apple .. .. .. × 100
102. Surface view of epidermis of Cleopatra, showing the remains of a single stoma in centre of lenticels forming .. .. × 100
103. Surface view of epidermis of Yates, showing single stoma and lenticels forming .. .. × 100
104. Surface view of epidermis of Yates, showing lenticels .. .. × 100
105. Surface view of epidermis of Cleopatra, showing the thick walled mother-cells divided into the thinner walled daughter-cells, known as "Window-cells" from their appearance .. .. × 100
106. Cross section of skin of Cleopatra, showing epidermis and sub-epidermis, into which the ultimate branchlets of the vascular bundles penetrate .. × 100
107. Cross section of skin after immersion of Cleopatra Apple in citric acid .. × 100
108. Surface view of epidermis of Pear, showing the "Window-cells" as in the Apple, but somewhat smaller .. .. × 100
109. Cross section through skin and flesh of Pear, showing epidermis and sub-epidermis together with groups of "Stone-cells" in the flesh .. × 100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XVIII. —VARIOUS CAUSES ASSIGNED FOR BITTER PIT.

(Figs. 110, 111.)

PLATE XIX.

Fig.

110. General view of Apple trees enclosed in mosquito netting and cheese cloth to prevent the access of insects.

111. Annie Elizabeth tree with 58 clusters of Apples, which were enclosed in white calico bags as soon as the fruit had set to protect it from birds, insects, &c.


111


110

XIX.—DETERIORATION OF THE APPLE-TREE VARIETIES.

(Figs. 112–118.)

PLATE XX.

Fig.

112. Rymer Apple Tree, 40 years old. (Lang's Orchard, Harcourt, 27.3.12.)

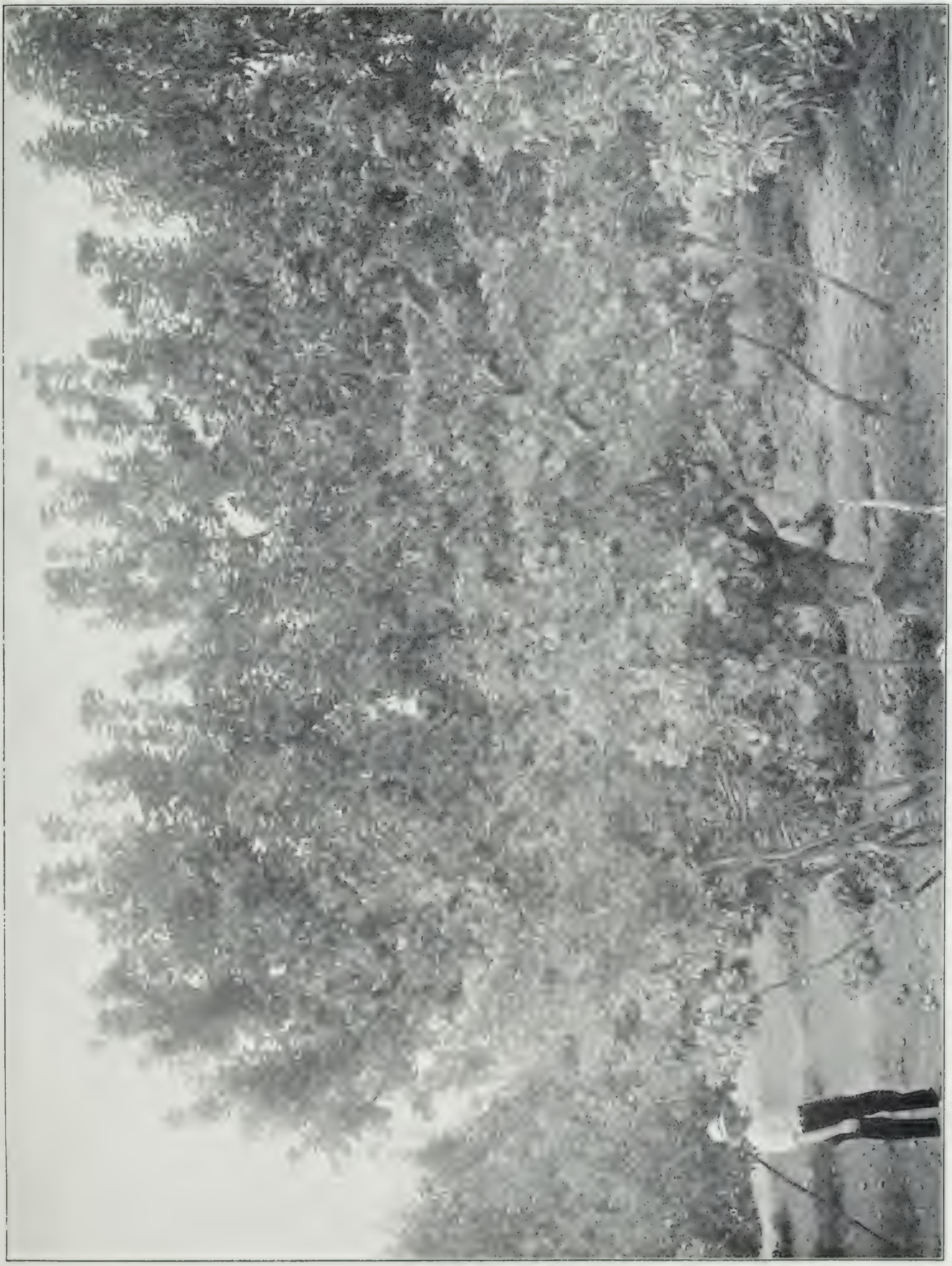

Fig. 112

PLATE XXI.

Fig.

113. Dumelow's Seedling Apple Tree, 50 years old. (Lang's Orchard, Harcourt, 27.3.12.)

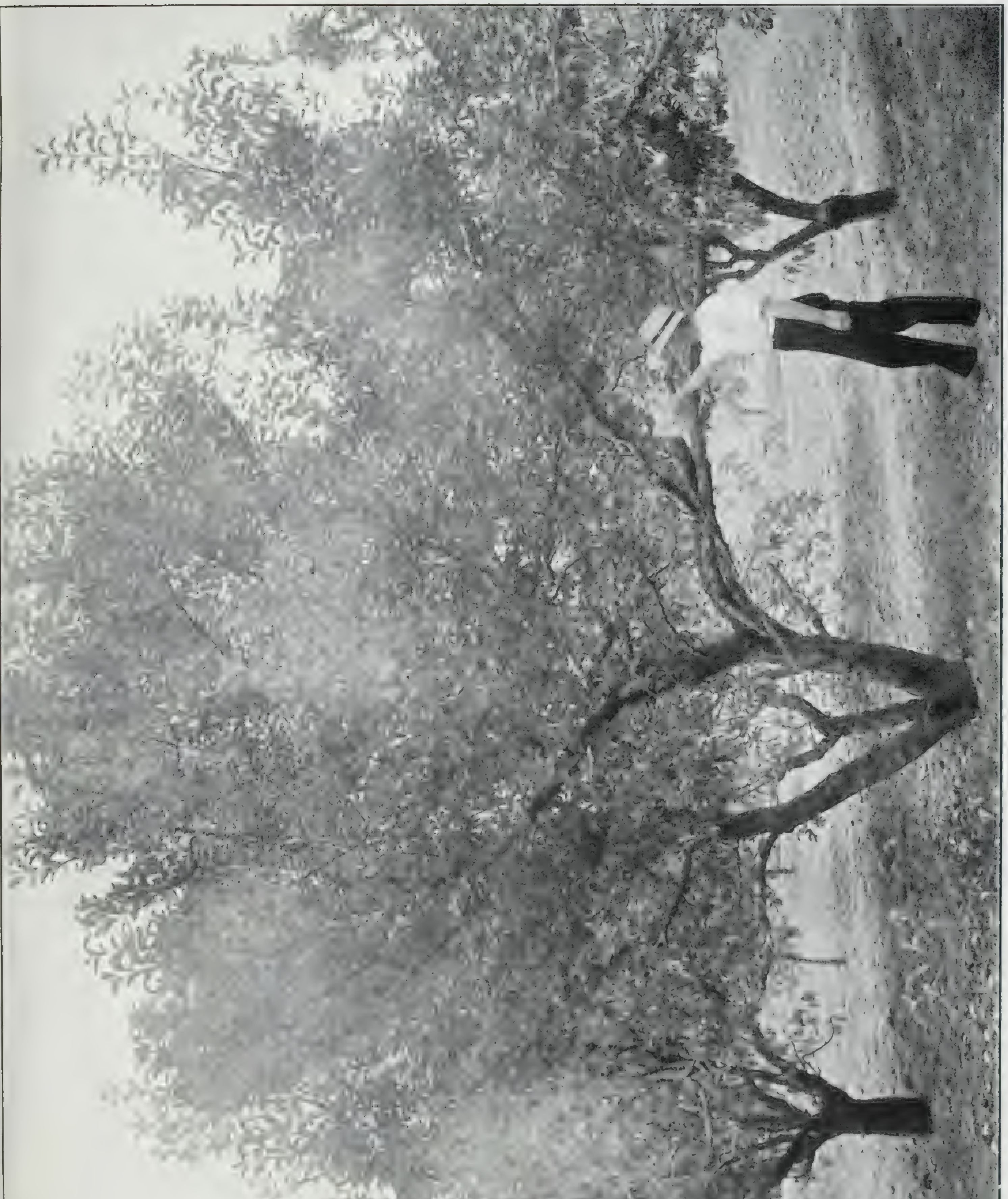

Fig. 113

PLATE XXII.

Fig.
114. Broompark Pear Tree, 50 years old. (Lang's Orchard, Harcourt, 27.3.12.)

Fig. 114

PLATE XXIII.

Fig.

115. Ne Plus Meuris Pear Tree, in front of Broompark and planted at the same time, 50 years old. (Lang's Orchard, Harcourt, 27.3.12.)

Fig. 115

PLATE XXIV.

Fig.

116. Pear Tree, over 50 years old, growing in a lane off Collins-street, Melbourne, surrounded by tall buildings, and still bearing healthy fruit. (15.5.12.)


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Fig. 116

PLATE XXV.

Fig.

117. Old Apple Tree, at least 70 years of age, and one of the earliest fruit trees planted in Victoria. (12.5.12.)

118. Purity Apple Tree, over 60 years old. (From photograph by A. G. Campbell.)


117


118

XXII.—EXPERIMENTS WITH A VIEW TO CONTROLLING THE DISEASE.

(Figs. 119–133.)

PLATE XXVI.

Fig.

119. General view of Experiment Block at Mr. H. H. Hatfield's Orchard, Box Hill, Victoria. It is situated at the right of the row of pine trees.

120. Application of Lime round eight Apple Trees.

121. Pruning Experiments at Burnley Horticultural Gardens—Five Crown or London Pippin.

(*a*) Severe Pruning.
(*b*) Light Pruning.
(*c*) Leader Pruning.
(*d*) No Pruning.


119
120
121 A
B
C
D

PLATE XXVII.

Fig.

122. Produce of three Cleopatra Trees in each experiment plot at Deepdene, near Melbourne—Unsprayed—

(*a*) Severe Pruning	..	31 Apples, 3 with Bitter Pit.
(*b*) Light Pruning	..	41 Apples, 5 with Bitter Pit.
(*c*) Leader Pruning	..	33 Apples, 2 with Bitter Pit.
(*d*) No Pruning ..	..	28 Apples, 1 with Bitter Pit.

123. Cleopatra unpruned for the past ten years at Bathurst Experiment Farm, New South Wales. (From photograph by G. H. Johnston.)

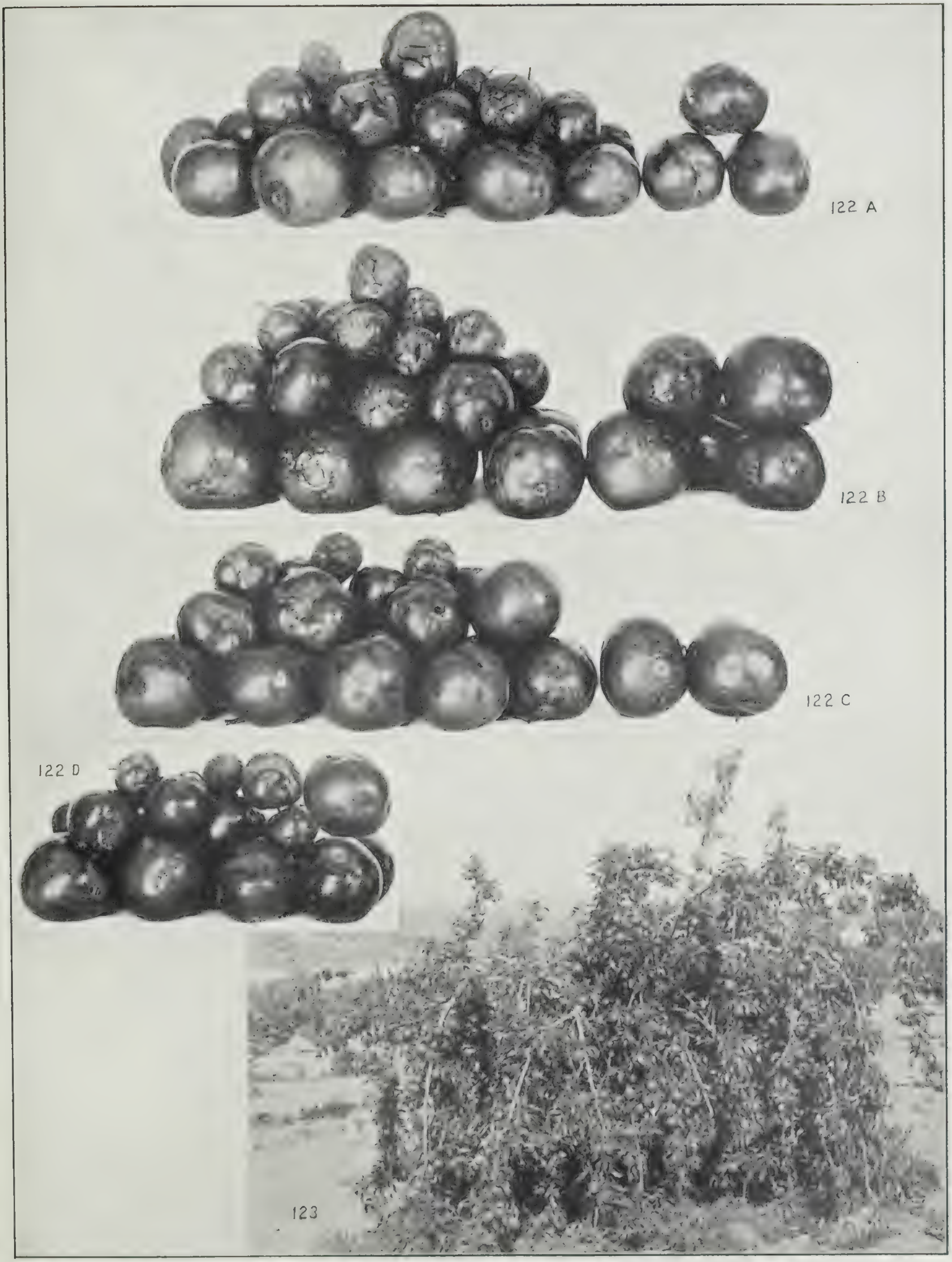
122 A
122 B
122 C
122 D
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PLATE XXVIII.

Fig.

124. Experiments with various Stocks in bird-proof enclosure.

(*a*) Just after Planting.
(*b*) The same after being Pruned.


124 B
124 A

PLATE XXIX.

Fig.

125. Bark-grafting on Winter Majetin of four different scions liable to Bitter Pit, viz., Cleopatra, Annie Elizabeth, Cox's Orange Pippin, and Prince Bismarck.

126. Gravensteins on Northern Spy Stock, showing twisted and distorted branches. (Diamond Creek, 13.5.12.)

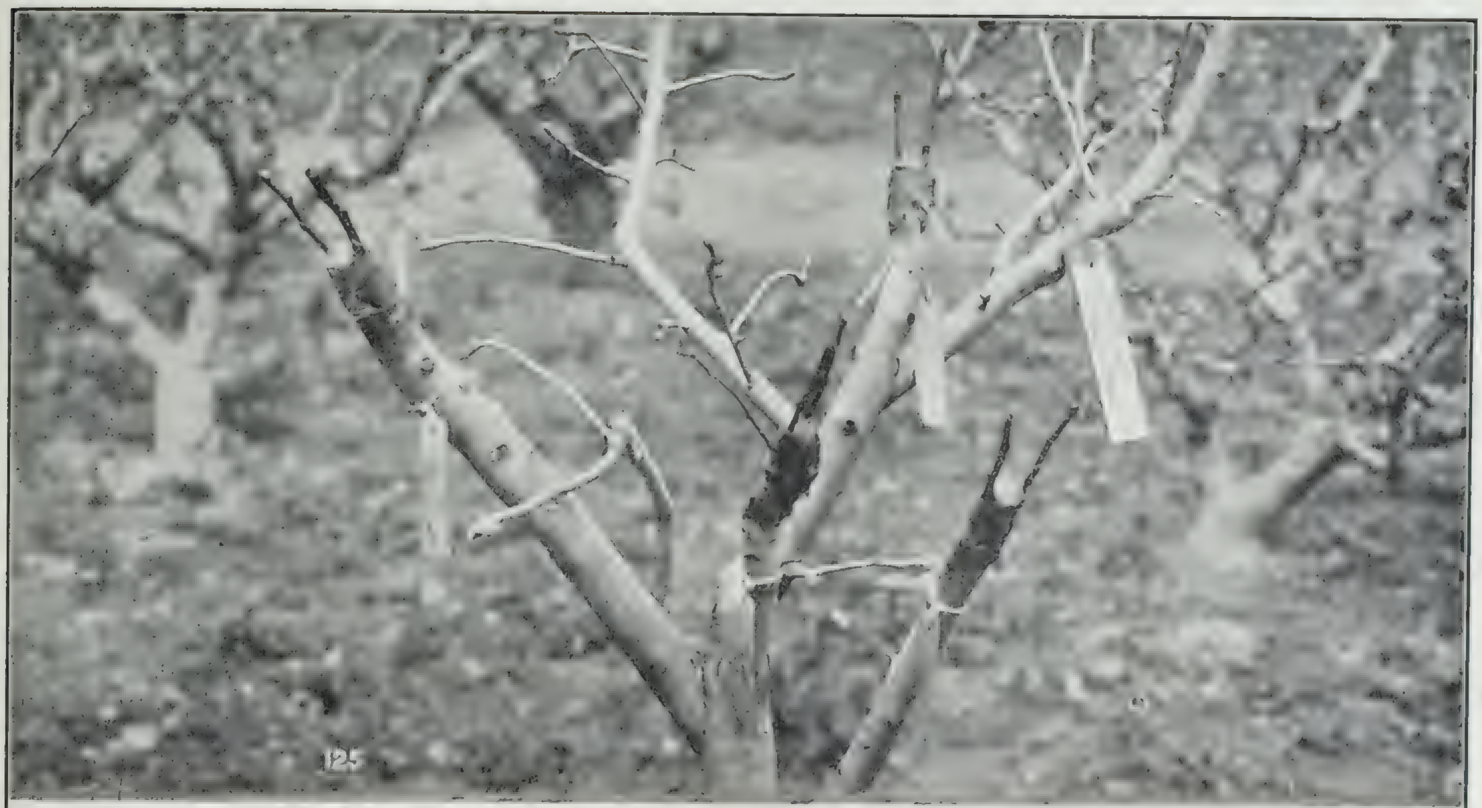
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PLATE XXX.

Fig.

127. Gravenstein, first tree in row—10 feet high, and trunk $4\frac{1}{2}$ inches in diameter.

Fig. 127

PLATE XXXI.

Fig.

128. Close view of portion of third tree in row, showing badly twisted and gnarled limbs.

Fig. 128

PLATE XXXII.

Fig.

129. Gravenstein, in same row, on Northern Spy Roots, with regular branching and no twisting—22 feet high, and butt 11 inches in diameter.

Fig. 129

PLATE XXXIII

Fig.

130. Skeleton of Apple Leaf (Emperor Alexander).
131. Esopus Spitzenberg Apple, showing "Pits" due to bacteria at stalk end.
132. Prince Bismarck on Northern Spy Roots, one year from planting.
133. Prince Bismarck Tree, 11 years old, removed from the soil to show root-system.

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APPENDICES.

APPENDIX I.

GENERAL SCHEME OF BITTER PIT INVESTIGATION.

CIRCULAR No. 1.

There is such a conflict of opinion as to the cause of Bitter Pit, and consequently of the measures to be taken in dealing with it, that it is absolutely necessary to have some solid foundation of fact to go upon. I propose, therefore, to carry out a series of exact experiments and systematic observations, both in the laboratory and in the orchard.

In the orchard those factors will receive first attention which are more or less within the control of the orchardist himself, and here I wish to point out that the mistake is often made in studying this disease, of confining attention entirely to the fruit of the apple or pear, whereas the fruit is only the outcome of various antecedent conditions, so that every possible factor which contributes to the growth of the tree, as well as the formation of fruit, will require to be taken into account.

There are three principal lines of investigation that will be followed, viz. :—Manuring, pruning, and stocks for propagation.

1. The influence of *manures* or different kinds of plant food on the development of the disease.
2. The influence of different methods of *pruning* in regulating the distribution of the fruit on the tree, as well as the nutritive juices to different parts.
3. The internal factor or *heredity* will be studied, in so far as it is influenced by the variety or the *stocks* used for propagation.

Attention will also be paid to the influence of different *cultural methods* in conserving the moisture for the use of the tree when most wanted, and promoting uniform growth. The question of plant food is closely associated with that of soil-moisture, and the available quantity of moisture determines, in a large measure, whether the fruit will reach its normal size or not.

Experiments on these main lines will be started at once in the different States concerned, and various theories as to the cause of Bitter Pit will be tested, as well as various practices, which have an influence upon it.

Among other things, investigations will be undertaken during the coming season to settle the question—how, when, and where does the disease first appear in the fruit ?

There are numerous other experiments to be carried out in due course, but the point I wish to insist on is this, that the main object of these experiments will be to determine, as far as possible, what practices are beneficial, and thus arrive at some reasonable and practicable means of dealing with this menace to the fruit industry.

APPENDIX II.

BITTER PIT INVESTIGATION.

CIRCULAR No. 2.

I.—MANURING.

Experiments to be conducted with trees of the same variety, similar in age and size, all in bearing, and liable to Bitter Pit.

The object of these manurial experiments is primarily to test the effect of different manures on the development of Bitter Pit, but, incidentally, they will show what manure gives the best yield.

Experiments in the manuring of fruit trees have hitherto been comparatively neglected in Australia, and, if carried out properly in the different States for three or four seasons at least, they should yield valuable results. A well-balanced ration is just as necessary for the healthy growth of the plant as for that of the animal, and, where an excess of nitrogen is applied, the Bitter Pit is found to be more prevalent. On the other hand, in applying bone dust alone, as is often done, some of the essential plant foods are omitted.

The manures should be well worked into the soil, so as to bring them within reach of the feeding roots of the tree, and, in well established trees, the fertilizer should be equally distributed, starting about 3 or 4 feet from the trunk and extending beyond the spread of the branches. They should be applied before the stored up food in the tree is exhausted, and in my experiments hitherto, July and August were the months chosen.

In calculating quantities per tree from the number of trees per acre, it will only be necessary to work them out to the nearest lb., or fraction of a lb., not less than ¼. At least eight or ten trees should be used for each plot, and the necessary number of packets can be made up, containing the manure to be applied to each tree.

The proportions of the different manures used are for trees in full bearing, and, while the particular quantities best suited to the needs of any particular soil can only be determined by special experiments, the comparative results obtained by adopting a general formula for average soils will indicate the effect of the different combinations on the disease.

The best relative proportion of each ingredient cannot be definitely stated, but from the well-known effect of nitrogen on this disease, and the singular deficiency of phosphoric acid in our soils, in the complete manure here used, the former is reduced and the latter well supplied.

In the following experiments to be carried out there are nine variously treated plots, with a check plot on each side acting as a guard, so that there are altogether 19 plots, and, if 8 trees are allowed for each, the total is 152 trees. Of course if such a block cannot be found fulfilling all the requirements, then as many plots as possible should be tried. Special manures, such as sulphate of iron, could be tested separately.

II. PRUNING.

While Bitter Pit may occur on both pruned and unpruned trees, it is nevertheless desirable to test the relative effects of severe pruning, light pruning, and no pruning at all on this disease.

A variety in full bearing and liable to Bitter Pit should be chosen, and at least ten to twelve trees experimented on for each style of pruning.

For our purpose, a row of Five Crowns about ten years old was selected and treated as follows on 8th August :—

1. *Severe Pruning.*—The head pruned well back, the laterals considerably shortened, and all fruit spurs thinned.
2. *Light Pruning.*—Shortening back the leaders, removing unnecessary laterals, and leaving the rem ining laterals untouched.
3. *Leader Pruning.*—The leaders and main limbs lightly tipped.
4. *No Pruning.*—The entire tree untouched.

III.—STOCKS.

The reciprocal influence of stock on scion, as far as this disease is concerned, will be dealt with in an experimental way. The generally used blight-proof stock—Northern Spy—is known to be a variety very liable to Bitter Pit, and, while certain apples grown on other stocks are not free from the disease, still, it will be instructive to test the effect of various stocks on the varieties worked on them.

Owing to the limited period of the investigation, these experiments cannot be carried very far, but it is believed that, after a couple of seasons of fruit bearing, there is likely to be some evidence of the effect of the particular stock on the development of the disease. It is only from experiments already begun in this direction that immediate results can be expected, and I understand that Mr. Quinn, of South Australia, has some such experiments under way. Mr. Pescott, Principal of the School of Horticulture, Burnley, Victoria, has also begun preparing various stocks for experimental purposes, and he has kindly placed them at my disposal. By utilizing these stocks, some practical results may be obtained bearing on the problem, even within a limited period of time.

Experiments have now been commenced with the following :—

1. Stocks grafted and planted.
2. Stocks budded for planting out next year.
3. In addition to this, half-a-dozen different stocks have been selected for experiment, and, by working the same, liable varieties on each, it will be seen in course of time how the fruit grown from each is affected.

The stocks are Northern Spy, Winter Majetin, French Paradise, Duchess d'Oldenburg, Lord Wolseley, Crab or Free Apple stock. On each of these stocks the following four varieties have been cleft-grafted respectively, viz. :—Annie Elizabeth, Cleopatra, Cox's Orange Pippin, and Prince Bismarck, which are chosen on account of their being the worst in the orchard for Bitter Pit.

APPENDIX III.

BITTER PIT INVESTIGATION.

CIRCULAR No. 3.

Pathologist's Branch,
Melbourne, 15th August, 1911.

Having been appointed to investigate throughout the Australian States the disease in apples and pears commonly known as Bitter Pit, a disease which causes serious loss and is particularly injurious to our export trade, it has been deemed advisable, at the outset, to issue a series of questions which will enable every fruit-grower to assist in the inquiry by giving the benefit of his knowledge and experience for the general good.

You are requested to return the answers to the enclosed questions at your earliest convenience, and oblige,

D. McALPINE.

QUESTIONS REGARDING BITTER PIT.

1. How long have you been growing Apples and Pears ?
2. Have your Apples or Pears been affected at any time with Bitter Pit ?
3. If not, what reason do you assign for its absence ?
4. If it does occur, what varieties of Apples and Pears do you grow, and which are affected with Bitter Pit, arranging them according as they are very bad, bad, or slightly affected ?
5. What varieties have you found absolutely free from it ?
6. In what year did the disease first make its appearance in Apples and Pears respectively ?
7. At what age of the trees have you found the fruit affected ?
8. At what stage of the growth of the fruit was the disease first observed ?
9. Have you noticed the disease to be worse when the individual tree is bearing a light crop or when bearing a heavy one ?
10. Name varieties in which the disease only appears in store ?
11. When Pit develops in storage, have you found it mostly on the surface or deep-seated ?
12. What is the nature of the soil and subsoil in your orchard ?
13. Have you noticed any difference in the prevalence of Bitter Pit in different classes of soils ?
14. Has manure, whether as ploughed-in green stuff, stable, or artificial, any effect upon the disease ?
15. Have you noticed any difference, as regards disease, between manured and unmanured trees ?
16. Have you applied lime to trees subject to this disease, and with what result ? Have you tried lime and green manuring combined ?
17. Have you found arsenical spraying to mark the fruit in any way ?
18. Has drainage any effect upon the prevalence of the disease ?
19. Has the mode of cultivation any influence on the disease ?
20. Has the system of pruning, whether severe or light, any influence on the disease ?
21. Is the disease affected by the stock used, and have you ever tried working a variety liable to the disease on different stocks ?
22. Have you observed whether colonial seedlings are particularly subject to the disease ?
23. Have you observed the disease on any other fruits than Apples and Pears ?
24. What other diseases have you observed associated with Bitter Pit ?
25. Was Bitter Pit particularly prevalent in your orchard during 1910–11 ? If so, what loss did you sustain ?
26. Which was the worst season you have experienced with this disease ? In what years was it most prevalent, and were they wet or dry seasons ?
27. Is it on the increase in your orchard or district ?
28. Have you formed any idea as to the cause of Bitter Pit ?
29. Any other remarks ?

Name—
Postal Address—
State—
Date—

APPENDIX IV.

AUSTRALIAN SEEDLING APPLES IN THEIR RELATION TO BITTER PIT.

Note.—All these seedlings are growing in the Burnley Gardens, with the exception of those marked with an asterisk.

Name.	By whom Raised.	Where.	When.	Liability to Bitter Pit at Burnley Gardens.	Remarks.
1. Allsop's Beauty ..	Came up at rear of J. Read's orchard in the bush	Pennant Hills, N.S.W.	About 1885	..	This apple was afterwards grafted and distributed by Mr. J. Allsop
2. Autumn Tart ..	J. C. Cole ..	Richmond, Vic.			
3. Beatrice	.. .. ..	Tasmania			
*4. Beauty of Australia	R. Whatmough ..	Greensborough, Vic.	1860		
5. Belmore Pippin ..	Fankhauser ..	Balwyn, Vic. ..	..	Slight	
6. Ben Lomond ..	.. .. ..	Tasmania			
7. Blondin	H. U. Cole ..	Hawthorn, Vic. ..	1880		
8. Borrowdale ..	H. U. Cole ..	,, ..	.. ..	Very bad	Fruited for first time in Gardens, 1890
9. Bunce	Dr. Bunce, Director, Geelong Botanical Gardens	Geelong, Vic. ..	1875		
10. Burwood	.. .. ..	Victoria			
11. Chandler	.. .. ..	.. .. ..	.. ..	.. ..	See No. 82
12. Cheltenham Pippin	Wells	Victoria	.. ..	Slight	
13. Cobrico	T. P. Errey ..	Cobrico, Vic.			
*14. Craike's Seedling ..	Thomas Craike ..	Strathfieldsaye, Vic.	1870		
15. Creasey's Seedling	.. .. ..	Victoria ..	.. ..	Slight	
16. Dennis Seedling ..	R. V. Dennis ..	Birregurra, Vic. ..	.. ..	Bad	
17. Donaldson's Seedling	Donaldson ..	Woodbrook, Vic.			
*18. Draper's Best ..	Charles Draper ..	Arthur's Creek ..	1876		
19. Duke of Clarence ..	.. .. ..	Tasmania			
20. Dundonald ..	John Ross ..	Ballarat, Vic.			
21. Eagle's Seedling ..	Wm. Eagle ..	Harcourt, Vic. ..	.. ..	.. ..	Original tree still growing
22. Early Richmond ..	J. C. Cole ..	Richmond, Vic.			
23. East End.. ..	T. C. Cole ..	Hawthorn, Vic. ..	1883		
24. Eddy's Favorite ..	John Eddy ..	Hartwell, Vic.			
25. Edwin	J. Hunter ..	Tally Ho, Vic.			
26. Fair Ellen ..	R. Whatmough ..	Greensborough, Vic.			
27. Fall Beauty ..	J. C. Cole ..	Richmond, Vic.			
28. Foster	Foster	Gippsland, Vic.			
29. Garibaldi (Chapman's) or Adelaide Garibaldi	Mr. Andrewartha ..	Uraidla, S.A. ..	.. ..	Very slight	It was named thus owing to its resemblance to the red shirt of the Italian patriot
30. George Neilson ..	C. Draper ..	Arthur's Creek			
31. Granny Smith ..	T. Smith ..	Ryde, N.S.W. ..	About 1862	Bad (at times)	When this apple was first put on the market, Mrs. Smith (who was always called Granny Smith) was selling there. It took her name, and has held it ever since

APPENDIX IV.—Australian Seedling Apples in their Relation to Bitter Pit—*continued.*

Name.	By whom Raised.	Where.	When.	Liability to Bitter Pit at Burnley Gardens.	Remarks.
32. Harcourt Pippin	Samuel Sutton	Harcourt, Vic.	1870		
33. Hunter's Choice	J. Hunter	Tally Ho, Vic.	..	Bad	
34. Huon Mystery	.. ..	Tasmania			
35. Jackson's Seedling	.. ..	Victoria			
36. John Toon	Shepherd	Somerville, Vic.			
37. Jubilee ..	Jas. Brimmer	Ararat, Vic.	..	..	Fruited for first time in Gardens, 1890
38. Kew Pippin	J. Carson	Studley Park, Vic.			
39. Lady Carrington ..	Jas. Smith, jun.	Pennant Hills, N.S.W.	About 1882	..	The butt of the original tree is still alive
40. Lady Daly ..	Sir R. D. Ross	Highercombe, near Houghton, S.A.	About 1862	..	Named after Lady Daly, wife of Sir Dominic Daly, a former Governor of South Australia
41. Lady Hopetoun ..	Schroeder	Castlemaine, Vic.			
42. Lapsley Pearmain ..	Lapsley ..	Lockwood, Vic.			
43. Lara ..	Currie ..	Lara, Vic.			
44. La Trobe	T. C. Cole	Hawthorn, Vic.	1883	Slight	
45. Late Aromatic ..	Charles Stone	Brighton ..	1870		
46. Late Winter (Cole's)	T. C. Cole	Hawthorn, Vic.	1883		
47. Magg's Seedling ..	Magg ..	Ringwood, Vic.	..	Bad	
48. Maid of Hawthorn	T. C. Cole	Hawthorn, Vic.	1883		
49. Mellon's Seedling ..	F. Mellon	Dunolly, Vic.	..	..	A seedling from Stone Pippin
50. Morgan's Seedling ..	Morgan ..	Nunawading, Vic.			
51. Mt. Macedon Codlin	Robertson	Macedon ..	1860		
52. Munroe's Favorite or Dunn's Seedling	Munroe .. Dunn ..	Strathloddon, Vic. Glen Ewen, near Houghton, S.A.	1868	Slight ..	This apple was raised between 50 and 60 years ago by Mr. Dunn, at Glen Ewen, near Houghton, S.A. It is supposed to be a chance seedling from the Stone Pippin, which it resembles
53. Newman's Seedling	C. F. Newman	Near Inglewood, S.A.	About 1852		
54. Northern Spy Seedling	Geo. Neilson	Burnley, Vic.	..	Very bad	
55. Orange Nonpariel ..	H. U. Cole	Hawthorn, Vic.			
56. Paradise (Cole's Blight Proof)	J. C. Cole	Richmond, Vic.			
57. Pegg's Seedling	Pegg ..	Batesford, Vic.			
58. Perfection (Shepherd's)	Shepherd	Somerville Vic.		Slight	A seedling from Blenheim Orange, and the seed was forwarded from England in 1865
59. Pioneer ..	Wm. Chandler	Malvern, Vic.	1858		
60. Prince of the Pippins	H. U. Cole	Hawthorn, Vic.	1876		
61. Prince Alfred	.. ..	Tasmania			
62. Prince Arthur	C. Draper	Arthur's Creek, Vic.			
63. Prince Bismarck ..	F. Fricke	Carisbrook, Vic.	1862	Very bad	A chance seedling
64. Pymbles Seedling ..	.. ..	New South Wales			
65. Red Jacket	Lane's ..	Hillend, N.S.W.			
66. Ridgway's Red	Named by Ridgway	Magill, S.A.			Mr. Giles brought it from Tasmania in the very early days under another name, which was lost. Never known to take Bitter Pit
67. Rodney (Kialla) ..	Furphy ..	Tylden ..	..	..	Propagated at Kialla

APPENDIX IV.—Australian Seedling Apples in their Relation to Bitter Pit—*continued.*

Name.	By whom Raised.	Where.	When.	Liability to Bitter Pit at Burnley Gardens.	Remarks.
68. Rokewood ..	John Bullock ..	Rokewood, Vic. ..	1873	.. ..	Fruited first at Rokewood in 1876. Original name Bullock's Seedling
69. Royal Oak ..	T. C. Cole ..	Hawthorn, Vic. ..	1883	Slight	
70. Ruby Pearmain ..	J. C. Cole ..	Richmond, Vic.			
71. Scarlet Queen ..	H. U. Cole ..	Hawthorn, Vic. ..	.. ..	Bad	
72. Schroeder's Apfel ..	Schroeder ..	Castlemaine, Vic.			
73. Schroeder's Seedling	Schroeder ..	Castlemaine, Vic.			
74. Selector	J. D. Love ..	Tatura, Vic. ..	1875		
75. Shorland Eclipse ..	H. U. Cole ..	Hawthorn, Vic. ..	.. ..	Slight	
76. Shorland Pearmain	H. U. Cole ..	,,			
77. Shorland Queen ..	H. U. Cole ..	,, ..	1875		
78. Shorland Reinette	H. U. Cole ..	,, ..	.. ..	Very bad	
79. Sir Henry Parkes	.. .. ..	New South Wales			
80. Smith's Early Red	.. .. ..	.. .. ..	.. ..	.. ..	This apple is said to be identical with Lady Carrington
81. Smith's Midseason or Smith's Second Seedling	Jas. Smith, jun. ..	Pennant Hills, N.S.W.	About 1877		
82. Statesman ..	Wm. Chandler ..	Malvern, Vic. ..	1858	Bad	This apple was first named Chandler, but as an American variety had the same name, it was changed to Statesman
83. Stewart's Seedling	Mrs. Stewart ..	Golden Point, Ballarat, Vic.	.. ..	Bad ..	A seedling of Munroe's Favorite
84. Stone's Harcourt Favorite	.. .. ..	Victoria			
*85. Sunbeam ..	J. H. Lang ..	Harcourt	1900		
86. Thompson's Long Keeper	Rev. H. Thompson	Tasmania	.. ..	Bad	
87. Transparent (Cole's)	T. C. Cole ..	Hawthorn, Vic. ..	1883		
88. Trivett's Seedling ..	.. .. ..	New South Wales			
89. Twyford Beauty ..	T. C. Cole ..	Hawthorn, Vic.			
*90. Twyford Spy ..	J. C. Cole ..	Richmond, Vic.			
91. Von Moltke ..	J. C. Cole ..	,, ..	.. ..	Slight	
92. Wandiligong Favorite	Taylor	Wandiligong, Vic. ..	.. ..	Very bad	
93. Weatherall's Pippin	Weatherall ..	Kew, Vic.			
*94. Western Belle ..	J. S. Parke ..	Warragul, Vic.	1895	.. ..	Northern Spy crossed with Late Wine
95. Whatmough's Pearmain	R. Whatmough ..	Greensborough, Vic.	1860		
96. William Anderson ..	Jas. Baker ..	Wandin Yallock, Vic.	.. ..	Very bad	
97. Woodstock Pippin	.. .. ..	Tasmania			
98. Yapeen Seedling ..	Holmes	Yapeen, near Castlemaine, Vic.			
99. Yarra Bank ..	Geo. Neilson ..	Burnley, Vic. ..	1874	Bad ..	A seedling of Winter Majetin not artificially crossed. Blight proof
100. Yeates' Nonpareil ..	T. Yeates ..	Muckleford, Vic. ..	1870		

APPENDIX V.

VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911-12.

Variety.	Stock.	Stage of Ripeness.	Firm or Soft-fleshed.	Early.	Mid-season.	Late.	How affected. Very Bad.	Bad.	Slight.	Remarks, with date of first appearance of Pit.
1. Albion	French Paradise on Spy roots ..	Half ..	Firm ..	..	M.	..	..	B.		
2. Alfriston	,, ,, ,, ..	,, ..	,, ..	..	..	L.	..	..	V.S.	
3. Allington Pippin ..	Lord Wolseley on Spy roots ..	,, ..	,, ..	..	M.	..	..	B.		
4. American Golden Pippin	French Paradise on Spy roots ..	,, ..	,, ..	..	M.	..	..	..	S.	Added to collection, 1877
5. Annie Elizabeth ..	*(1) Spy roots .. .. (2) Paradise on Spy	Third ..	Firm and crisp	..	..	L.	V.B.	..	..	29th December, 1911
6. Aromatic Quatford ..	French Paradise on Spy roots ..	Half ..	Firm ..	..	M.	..	..	B.		
7. Baldwin	,, ,, ,, ..	Third ..	,, ..	..	M.	..	..	B.	..	Added to collection, 1879
8. Banks Exhibition ..	,, ,, ,, ..	Half ..	Soft ..	..	M.	..	..	B.		
9. Barcelona Pearmain ..	,, ,, ,, ..	Two-thirds ..	,, ..	..	M.	..	..	..	S.	
10. Bascombe Mystery ..	,, ,, ,, ..	Half ..	Firm ..	..	M.	..	..	..	S.	Bad when ripe
11. Battalion ..	Gravenstein on Northern Spy ..	Ripe ..	,, ..	..	M.	..	..	..	S.	Bad at Hatfield's orchard
12. Baxter's Pearmain ..	French Paradise on Spy roots ..	Half ..	,, ..	..	..	L.	V.B.			
13. Beachemwell ..	,, ,, ,, ..	,, ..	,, ..	..	M.	..	..	..	S.	
14. Belle Norman-Cider ..	,, ,, ,, ..	,, ..	,, ..	..	M.	..	B.			
15. Bentley's Sweet ..	,, ,, ,, ..	Ripe ..	,, ..	E.	..	..	..	..	S.	
16. Belmore Pippin ..	,, ,, ,, ..	,, ..	,, ..	..	..	L.	..	..	S.	
17. Blenheim Pippin ..	,, ,, ,, ..	Half ..	,, ..	..	M.	..	V.B.			
18. Blondin	Esopus Spitzenberg on Northern Spy	Ripe ..	,, ..	..	M. to	L.	..	B.		
19. Borrowdale ..	French Paradise on Spy roots ..	Nearly ripe ..	Soft ..	E.	..	..	..	B.	..	Earliest apple known in Victoria. Colonial seedling; first observed, 7th December, 1911
20. Boston Russet ..	(1) ,, ,, ,, .. (2) Cox's Orange Pippin on Spy	Half ..	Firm ..	..	..	L.	..	..	S.	
21. Brabant Bellefleur ..	French Paradise on Spy roots ..	,, ..	,, ..	..	..	L.	V.B.			
22. Bramley Seedling ..	,, ,, ,, ..	,, ..	,, ..	..	M.	..	V.B.	..	..	Added to collection, 1879
23. Brownlees' Russet ..	,, ,, ,, ..	Ripe ..	,,	..	M. to	L.	..	..	S.	In store
24. Bruce's Summer ..	,, ,, ,, ..	Half ..	,, ..	..	M.	..	V.B.			
25. Buncombe	(1) French Paradise on Northern Spy (2) Cox's Orange Pippin on Spy	Ripe ..	,, ..	..	..	L.	..	B.		
26. Calville Blanche d'Été	French Paradise on Spy roots ..	,, ..	Soft ..	E.	..	..	V.B.	..	..	Added to collection, 1882 —14th December, 1911
27. Cammack's Sweet ..	,, ,, ,, ..	,, ..	Firm ..	..	..	L.	..	..	V.S.	
28. Castle Major ..	,, ,, ,, ..	Half ..	,, ..	E.	..	..	..	B.		
29. Cat's Head	,, ,, ,, ..	,, ..	,, ..	E. to	M.	..	..	B.	..	Added to collection, 1879
30. Chalk's Ton ..	Perfection (Shepherd's) on French Paradise	,, ..	,, ..	..	M.	..	V.B.			

* Figures in brackets indicate trees on different stocks.

APPENDIX V.—VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911–12—*continued.*

Variety.	Stock.	Stage of Ripeness.	Firm or Soft-fleshed.	Early.	Mid-season.	Late.	How affected. Very Bad.	Bad.	Slight.	Remarks, with date of first appearance of Pit.
31. Cheltenham Pippin ..	French Paradise on Spy roots ..	Half ..	Firm to soft	E.	..	..	..	..	S.	Added to collection, 1878
32. Cheoce	,, ,, ,, ..	Third ..	Firm ..	..	M.	..	..	..	S.	
33. Chestoa	,, ,, ,, ..	Ripe ..	,, ..	..	..	L.	..	..	S.	
34. Claygate Pearmain ..	,, ,, ,, ..	Half ..	,, ..	..	M.	..	..	B.		
35. Cleopatra (Syn. Ortley)	,, ,, ,, ..	Third ..	,, ..	..	M. to L.		..	B.	..	Very bad when ripe. A second tree is on the original roots, the tree being imported from America; stock unknown
36. Condom	,, ,, ,, ..	Half ..	,, ..	..	M.	..	..	B.	..	Added to collection, 1879
37. Cornish Gilliflower ..	,, ,, ,, ..	,, ..	Firm and hard	..	M.	..	..	..	S.	
38. Cox's Orange Pippin	Northern Spy roots	Ripe ..	Firm ..	..	M.	..	..	..	S.	Brought from Burwood, 10th February, 1912.
39. Creasey's Seedling ..	French Paradise on Spy roots ..	Third ..	,, ..	..	..	L.	..	..	S.	
40. Dartmouth Crab ..	Northern Spy roots	Three-quarters	,, ..	..	M.	..	..	B.	..	First observed, 7th December, 1911
41. Deitzer's Golden Reinette	French Paradise on Spy roots ..	Half ..	,, ..	..	M.	..	..	..	S.	
42. Dennis Seedling ..	,, ,, ,, ..	Ripe ..	Soft ..	..	M.	..	..	B.	..	Added to collection, 1885
43. Dellington Beauty ..	,, ,, ,, ..	Half ..	Firm ..	..	M.	..	..	B.	..	Added to collection, 1879
44. Disharoon	,, ,, ,, ..	Ripe ..	,, ..	..	M.	..	..	B.		
45. Dr. Hogg	,, ,, ,, ..	Two-thirds ..	,, ..	E.	..	..	..	B.	..	One of the best of dessert apples. Added to collection, 1885
46. Duke of Devonshire ..	,, ,, ,, ..	Half ..	,, ..	..	M.	..	V.B.	..	..	Added to collection, 1877
47. Dumelow's Seedling ..	(1) Cox's Orange Pippin on Spy (2) French Paradise on Spy roots	Third ..	Firm and hard	..	M.	..	..	B.		
48. Dutch Mignonne ..	French Paradise on Spy roots ..	Half ..	Firm ..	..	M.	..	..	..	V.S.	
49. Early Almond ..	(1) ,, ,, ,, .. (2) Prince Bismarck on Spy roots	Ripe ..	Soft ..	E.	..	..	..	B.		
50. Early Green Hayes ..	French Paradise on Spy roots ..	Half ..	Firm ..	..	M.	..	..	B.		
51. Ecklinville Seedling ..	,, ,, ,, ..	,, ..	,, ..	E.	..	..	..	..	S.	14th December, 1911
52. Edgar's Red Streak ..	,, ,, ,, ..	Ripe ..	,, ..	..	M.	..	V.B.	..	..	Added to collection, 1885
53. English Golden Pippin	,, ,, ,, ..	Half ..	,, ..	..	..	L.	..	..	S.	
54. Esopus Spitzenberg ..	Northern Spy roots	,, ..	,, ..	..	..	L.	..	..	S.	When ripe, some of the apples were badly pitted
55. Fairleigh Pippin ..	,, ,, ...	Ripe ..	,, ..	..	..	L.	..	B.		
56. Fairy	,, ,, ...	Half ..	,, ..	..	..	L.	..	..	V.S.	Added to collection, 1885
57. Fanny	French Paradise on Spy roots ..	Three-fourths	,, ..	E.	..	..	..	B.		
58. Fillbasket	,, ,, ,, ..	Nearly ripe ..	,, ..	..	M.	..	V.B.	..	..	Added to collection, 1879
59. Filby Seedling ..	,, ,, ,, ..	Half ..	,, ..	..	M.	..	V.B.	..	..	,, ,, ,,
60. Five Crown or London Pippin	(1) French Paradise on Spy .. (2) Spy roots	Nearly ripe ..	,, ..	..	M. to L.		..	B. (occasionally)		Firm when picked, softens as it ripens

APPENDIX V.—VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911–12—*continued*.

Variety.	Stock.	Stage of Ripeness.	Firm or Soft-fleshed.	Early.	Mid season.	Late.	How affected.			Remarks, with date of first appearance of Pit.
							Very Bad.	Bad.	Slight.	
61. Fletcher's Crimson ..	French Paradise on Spy roots ..	Ripe ..	Firm ..	..	M.	..	..	B.		
62. Flower of Herts ..	Northern Spy roots	Nearly ripe ..	,, ..	..	M.	..	..	B.		
63. Forest Styre-Cider ..	French Paradise on Spy roots ..	Half ..	,, ..	..	..	L.	V.B.	..	..	Added to collection, 1878
64. Forfar Pippin ..	,, ,, ,, ..	,, ..	,, ..	..	M.	..	..	B.		
65. Frampton ..	,, ,, ,, ..	Ripe ..	,, ..	..	M.	..	..	..	S.	
66. French Crab ..	(1) Northern Spy roots .. (2) Lord Wolseley on Spy roots	,, ..	Hard ..	..	..	L.	..	B.		
67. Garden Royale ..	(1) French Paradise on Spy roots (2) Lord Wolseley on Northern Spy roots	Nearly ripe ..	Soft ..	E.	..	..	V.B.	..	..	Added to collection, 1879 —7th December, 1911, still green
68. Gascoigne's Scarlet ..	(1) Northern Spy roots .. (2) Cox's Orange Pippin on Spy roots	Ripe ..	,, ..	..	..	L.	V.B.			
69. Gladney's Red ..	French Paradise on Spy roots ..	,, ..	Firm ..	..	..	L.	..	..	S.	
70. Garibaldi (Chapman's)	,, ,, ,, ..	,, ..	,, ..	..	M.	..	..	..	V.S.	
71. Golden Queen ..	,, ,, ,, ..	Half ..	,, ..	..	M.	..	..	B.		
72. Granny Smith ..	Munroe's Favorite on French Paradise on Spy roots	Ripe ..	,, ..	..	..	L.	..	B.		
73. Gravenstein.. ..	(1) French Paradise on Spy roots (2) Spy roots	,, ..	Firm and juicy	E.	..	..	..	..	S.	
74. Harcourt Pippin (Sutton's)	French Paradise on Spy roots ..	,, ..	Soft ..	..	M.	..	..	..	S.	Added to collection, 1880
75. Hartford Sweet ..	,, ,, ,, ..	Third ..	Firm ..	..	M.	..	..	..	S.	Added to collection, 1878
76. Harvey's Seedling ..	,, ,, ,, ..	Ripe ..	,, ..	..	..	L.	..	..	V.S.	Added to collection, 1882
77. Harvey's Wiltshire Defiance	,, ,, ,, ..	Nearly ripe ..	,, ..	E.	..	..	..	..	S.	
78. Hawthornden (New French)	,, ,, ,, ..	Half ..	,, ..	..	M.	..	..	..	S.	Added to collection, 1879
79. Hawthornden (Murray's)	,, ,, ,, ..	,, ..	Soft ..	..	M.	..	..	..	S.	First observed, 8th December, 1911
80. Hockett's Sweet ..	,, ,, ,, ..	Third ..	Firm ..	..	M.	..	..	B.		
81. Hoover	,, ,, ,, ..	Ripe ..	Soft ..	..	..	L.	..	B.		
82. Hunter's Choice ..	Northern Spy roots	Half ..	Firm ..	..	M.	..	..	B.		
83. Huntingdon Codlin ..	French Paradise on Spy roots ..	,, ..	,, ..	E. to M.		..	V.B.	..	..	Added to collection, 1879
84. Izard's Kernel-Cider ..	,, ,, ,, ..	,, ..	,, ..	..	..	L.	..	B.	..	Added to collection, 1878
85. Julian	,, ,, ,, ..	Third ..	,, ..	..	..	L.	V.B.			
86. Kentucky	,, ,, ,, ..	Three-fourths	Soft ..	E.	..	..	..	B.	..	Added to collection, 1885
87. King David.. ..	(1) Perfection on Spy .. (2) Spy roots (3) Kentish Fillbasket on Paradise on Spy roots	Nearly ripe ..	Firm ..	E.	..	..	..	B.		
88. King of the Pippins ..	French Paradise on Spy roots ..	Two-thirds ..	,, ..	..	M.	..	..	B. to S.		
89. Kingston Black-Cider	French Paradise on Spy on Spy roots	Half ..	,, ..	..	..	L.	V.B.			
90. Kittageskie ..	French Paradise on Spy roots ..	,, ..	,, ..	..	..	L.	..	..	S.	
91. Lady Henniker ..	,, ,, ,, ..	,, ..	,, ..	..	..	L.	..	B.	..	Added to collection, 1878

APPENDIX V.—VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911–12—*continued.*

Variety.	Stock.	Stage of Ripeness.	Firm or Soft-fleshed.	Early.	Mid-season.	Late.	How affected. Very Bad.	Bad.	Slight.	Remarks, with date of first appearance of Pit.
92. Lady Hopetoun ..	Northern Spy roots	Nearly ripe ..	Firm ..	..	M. to	L.	..	..	S.	
93. Lamb Abbey Pearmain	French Paradise on Spy roots ..	Third ..	,, ..	..	..	L.	..	B.		
94. Lane's Prince Albert	,, ,, ,, ..	Half ..	Softish..	..	M.	..	V.B.	..	..	Ripe, and in store
95. La Trobe	,, ,, ,, ..	Third ..	Firm ..	..	M.	..	..	..	S.	Added to collection, 1885
96. Lewis' Incomparable	,, ,, ,, ..	Half ..	Soft to firm	..	M.	..	V.B.			
97. Loddington ..	,, ,, ,, ..	,, ..	Firm ..	E. to	M.	..	V.B.			
98. Lodgemore Nonpareil	,, ,, ,, ..	Ripe ..	,, ..	..	..	L.	..	..	S.	
99. Lord Burleigh ..	,, ,, ,, ..	Third ..	,, ..	..	M. to	L.	..	..	S.	
100. Lord Suffield ..	(1) Perfection on Spy roots .. (2) French Paradise on Spy roots	Ripe ..	Soft ..	E.	..	..	V.B.			
101. Lord Wolseley ..	(1) ,, ,, ,, (2) Spy roots	Third ..	Firm and crisp	..	..	L.	V.B.	..	..	A valuable apple, raised in New Zealand, said to be a cross between Stone Pippin and Irish Peach. Picked on 17th April, 80–90 per cent. pitted
102. Mabbott's Pearmain ..	French Paradise on Spy roots ..	Nearly ripe ..	Firm ..	..	M.	..	..	B.		
103. Magg's Seedling ..	,, ,, ,, ..	Third ..	,, ..	..	..	L.	..	B.	..	Added to collection, 1882
104. Mamma	,, ,, ,, ..	Half ..	,, ..	..	M.	..	..	..	S.	Added to collection, 1877
105. Maverick's Sweet ..	,, ,, ,, ..	,, ..	,, ..	..	..	L.	..	B.		
106. Micheleon	,, ,, ,, ..	,, ..	,, ..	..	..	L.	..	..	S.	
107. Minier's Dumpling ..	Spy roots—intermediate stock unknown	Ripe ..	,, ..	..	..	L.	..	B.	..	Added to collection, 1877
108. Monmouth Pippin ..	French Paradise on Spy roots ..	Half ..	Firm and hard	..	..	L.	..	..	S.	Imported from America in January, 1876
109. Moss Incomparable ..	(1) French Paradise on Spy roots (2) Prince Bismarck on Northern Spy	,, ..	Firmish	..	M.	..	..	B.		
110. Moultries or Indian Wonder	French Paradise on Spy roots ..	Ripe ..	Firm ..	..	..	L.	..	..	S.	
111. Munroe's Favorite or Dunn's Seedling	(1) On Spy .. .. .. (2) French Paradise on Spy roots	Over half ..	,, ..	..	..	L.	..	..	S.	Added to collection, 1880
112. Newtown Pippin, Green	French Paradise on Spy roots ..	Third ..	,, ..	..	..	L.	..	B.	..	Ripe, and in store
113. Newton Wonder ..	This was worked on a seedling, which ultimately proved useless, the seedling being on Spy roots	Half ..	,, ..	..	M.	..	..	B.		
114. Norfolk Storing ..	French Paradise on Spy roots ..	Ripe ..	,, ..	..	..	L.	..	..	S.	
115. Northern Spy ..	(1) French Paradise on Spy .. (2) Spy roots	Two-thirds ..	Soft to firm	..	M. to	L.	..	B.		
116. Northern Spy Seedling	French Paradise on Spy roots ..	Ripe ..	Softish..	..	M.	..	V.B.			
117. Occident	,, ,, ,, ..	,, ..	Firm ..	..	..	L.	..	B.		
118. Ord's Apple ..	,, ,, ,, ..	Third ..	Soft ..	..	M.	..	Exceedingly bad	..	..	Added to collection, 1885

APPENDIX V.—VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911–12—*continued.*

Variety.	Stock.	Stage of Ripeness.	Firm or Soft flesh.	Early.	Mid-season.	Late.	How affected. Very Bad.	Bad.	Slight.	Remarks, with date of first appearance of Pit.
119. Peck's Pleasant ..	French Paradise on Spy roots .	Ripe ..	Firm and hard	..	..	L.		B.		
120. Pickard's Reserve ..	,, ,, ,, ..	Hard	Firm	.	..	L.		..	S.	
121. Pine Apple Russett .	,, ,, ,, ..	Half ..	Soft to firm	..	M.			B.		
122. Pioneer	(1) French Paradise on Spy roots (2) Esopus Spitzenberg on Spy	Ripe ..	Firm ..	..	..	L.			V. S.	
123. Pomme Royale ..	French Paradise on Spy roots .	Half ..	,, ..	..	M.				S.	Added to collection, 1880
124. Prince Bismarck .	Northern Spy roots	Two-thirds	..		M.		V. B.			
125. Prince Rudolphe d'Autriche	,, ,, ,, ...	Half ..	Firmish		M.		V. B.			
126. Prinz Apfel ..	French Paradise on Spy roots ..	Two-thirds ..	Firm ..	..	M.	..		B.		Added to collection, 1879
127. Purity	.. ..	Ripe ..	,, ..		M.			B.		
128. Pymble's Seedling ..	,, ,, ,, ..	,, ..	,, ..	..	M.	..			S.	
129. Red Must-Cider ..	.. . . .	Half ..	,, ..	..	..	L.	V. B.			
130. Reinette a Feuilles d'Autriche	,, ,, ,, .	Two-thirds	Soft		M.			..	S.	Added to collection, 1885
131. Reinette Baumann.	,, ,, ,, ..	Hard .	Firm		M. to L.			..	S.	
132. Reinette de Canada ..	(1) Annie Elizabeth on Spy roots (2) French Paradise on Spy roots	Ripe ..	Soft ..	..	..	L.			V. S.	Store—two pits.
133. Reinette de Canada ..	.. .. .	Half ..	Firm to soft	..	..	L.		..	S.	Young tree
134. Rhodes' Orange .	French Paradise on Spy roots ..	. .	Firm	E.	.			..	S.	
135. Rhode Island Greening	(1) Cox's Orange Pippin on Spy (2) French Paradise on Spy	Ripe ..	Soft ..	..	M. to L.		V. B.			
136. Romanite .. .	French Paradise on Spy roots ..	Hard .	Firm	.	..	L.		B.		
137. Rome Beauty ..	(1) French Paradise on Spy roots (2) Munroe's Favorite on Spy roots (3) Spy roots	Ripe ..	.. ..	..	M. to L.			B.		Added to collection, 1878. [illegible]
138. Roundway Magnum Bonum	(1) Spy roots .. .. (2) French Paradise on Spy roots	Half ..	.. ..	..	M.	.		B.		
139. Royal Oak . .	French Paradise on Spy roots ..	Ripe ..	.. ..	..	..	L.			S.	Added to collection, 1885
140. Royal Sovereign ..	,, ,, ,, ..	Half .	..		M.	..		B. to S.		
141. Russet par Excellence	.. ,, ...	Ripe ..	Soft ..	..	M.	..		B.		
142. St. Albans Pippin ..	.. ,, ...	Half ..	Firm ..	..	M.	..	V. B.			Added to collection, 1879
143. Sandringham ..	,, ,, ,, ..	.. ..	.		M. to L.			..	S.	
144. Scarlet Queen	,, ,, ,, ..	Hard ..	..	..	M.	..	.	B.		
145. Seedling .. .	,, ,, ,, ..	Half ..	Firm and hard	..	M.	..	V. B.	.		Added to collection, 1879. Fruit bad all round tree
146. Senator . .	(1) Perfection on Spy roots .. (2) Spy roots	,, ..	Firm ..	..	.	L.	.	..	S.	
147. September Beauty .	French Paradise on Spy roots .	Third ..	Soft ..	E.			.	B.		22nd December, 1911, third ripe—bad. 8th January, 1912, very bad

APPENDIX V.—VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911–12—*continued.*

Variety.	Stock.	Stage of Ripeness.	Firm or Soft-fleshed.	Early.	Mid-season.	Late.	How affected: Very Bad.	Bad.	Slight.	Remarks, with date of first appearance of Pit.
148. Shepherd's Perfection	(1) French Paradise on Spy roots (2) Spy roots	Two-thirds	Firm	..	M.	..	..	..	V.S.	
149. Shiawasse Beauty	Gravenstein on Spy	Half	,,	..	M. to L.		..	B.		
150. Shockley	(1) Esopus Spitzenberg on Spy roots (2) French Paradise on Spy roots	Ripe	,,	..	..	L.	V.B.	..	..	One of the worst. Worked on an unknown variety, which was on Paradise on Spy roots
151. Shorland Eclipse	French Paradise on Spy roots	,,	,,	..	M.	..	..	..	S.	
152. Shorland Reinette	,, ,, ,,	Two-thirds	,,	..	M.	..	V.B.			
153 Sing's Seedling	Northern Spy roots	Ripe	,,	..	..	L.	..	..	S.	
154. Sir Richard-Cider	French Paradise on Spy roots	Half	,,	..	..	L.	..	B.		
155. Smith's Cider	,, ,, ,,	Ripe	,,	..	..	L.	..	..	S.	Imported from America in January, 1876. Only an occasional apple pitted
156. Somerset Lasting	,, ,, ,,	Half	Soft	..	M.	..	..	B.	..	Added to collection, 1879
157. Stark	This is the original tree which was imported from America about 1894–5, the stock being unknown	,,	Firm	..	M. to L.		V.B.			
158. Statesman	(1) Munroe's Favorite on Spy roots (2) French Paradise on Spy roots	Ripe	,,	..	..	L.	..	B.	..	Added to collection, 1880
159. Stayman's Winesap	(1) Gravenstein on Spy roots (2) Spy roots (3) Lord Wolseley on Spy roots	,,	,,	..	..	L.	..	..	S.	
160. Staten Rouge	French Paradise on Spy roots	Third	,,	..	M. to L.		..	..	S.	Added to collection, 1877
161. Stewarts' Seedling	(1) Lord Wolseley on Spy roots (2) Spy roots	Ripe	,,	..	..	L.	..	B.	..	Added to collection, 1880
162. Sturmer Pippin	(1) Prince Bismarck on Spy roots (2) Spy roots	Third	Soft	..	..	L.	..	B.		
163. Taccocee	Northern Spy roots	Ripe	Firm	..	M.	..	..	..	S.	
164. Taunton	,, ,,	,,	Soft	..	M.	..	..	..	S.	
165. Thompson's Long Keeper	(1) Hominy on French Paradise on Spy (2) Spy roots	,,	Firm	..	..	L.	..	B.		
166. Thorle Pippin	French Paradise on Spy roots	,,	,,	E.	..	..	..	..	S.	Without external sign
167. Tower of Glammis	,, ,, ,,	,,	,,	..	M.	..		B.		
168. Tuft's Baldwin	,, ,, ,,	Third	Soft	..	M.	..	V.B.	..	..	Added to collection, 1885
169. Twenty Ounce	(1) Cox's Orange Pippin on Spy roots (2) Spy roots	Ripe	,,	..	M.	..	..	B.	..	Imported from America, January, 1876
170. Tyler's Kernel	French Paradise on Spy roots	Two-thirds	Firm	..	M.	..	..	B.		
171. Von Moltke	,, ,, ,,	Ripe	Firm	..	M. to L.		..	..	S.	Added to collection, 1880
172. Washington	,, ,, ,,	Two-thirds	Soft	..	M.	..	..	B.	..	7th December, 1911
173. Wandiligong Favorite	,, ,, ,,	Ripe	Firm	..	..	L.	V.B.			
174. Watson's Dumpling	,, ,, ,,	Half	Firm	..	M.	..	V.B.			
175. Wagener	Northern Spy roots	Ripe	Soft	..	M.	..	..	..	V.S.	

APPENDIX V.—VARIETIES SUBJECT TO BITTER PIT AT BURNLEY HORTICULTURAL GARDENS, WITH CORRELATED CHARACTERS.—SEASON 1911-12—*continued*.

Variety.	Stock.	Stage of Ripeness.	Firm or Soft-fleshed.	Early	Mid	Late	How affected. Very Bad	Bad	Slight	Remarks, with date of first appearance of Pit.
176. Wealthy	(1) French Paradise on Spy roots (2) Spy roots (3) Perfection (Shepherd's) on Spy roots	Two-thirds ..	Soft		M	..	..	B.	..	Added to collection, 1885
177. Wells' Sweet ..	French Paradise on Spy roots ..	Third ..	Firm ..		M	L.	..	B		
178. Whatmough's Pearmain	.. ..	Ripe ..	Soft ..	..	M	.	..		V.S.	
179. White Transparent ..	,, ,, ,, ..	,, ..	,, ..	E.		..	..	B.	..	First observed, 7th December, 1911
180. William Anderson ..	(1) Ecklinville Seedling on Paradise on Spy (2) French Paradise on Spy roots (3) Sturmer Pippin on French Paradise on Spy	,, ..	Softish ..	..	M.	..	V.B.			
181. Williams' Favorite ..	(1) Prince Bismarck on Spy roots (2) Spy roots	.. ..	Firm ..	E.	..	..	..	..	S.	30th December, 1911 (Farrell). Ripe and edible
182. Willow Twig ..	French Paradise on Spy roots ..	,, ..	,, ..	..	M.	..	..	..	S.	Imported from America, January, 1876
183. Winter Peach ..	,, ,, ,, ..	.. ..	.. ..	..	..	L.	.	..	S.	
184. Wine	Northern Spy roots	,, ..	Very soft	.	M.	..	..	B.		
185. Winter Majetin ..	(1) French Paradise on Spy roots (2) Spy roots	,, ..	Soft ..	..	M.	..	..	..	S.	
186. Winter Strawberry ..	French Paradise on Spy roots ..	Half ..	,, ..	..	..	L.	..	B.		
187. Winter Strawberry Pippin	.. ..	Ripe ..	Softish ..	..	M	..	..	B.	..	Added to collection, 1882
188. Yarra Bank ..	(1) French Paradise on Spy roots (2) Spy roots	.. ..	Firm ..	..	M.	..	..	B.	..	Seedling raised at Burnley Gardens, 1883
189. Yeates' Nonpareil ..	French Paradise on Spy roots ..	Half ..	.. ..	..	M.	..	..	B.	..	Added to collection, 1880

By Authority: ALBERT J. MULLETT, Acting Government Printer, Melbourne.